

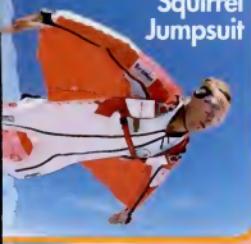
MARS MISSION: Cosmic Rays! Killer Dust! Cabin Fever! +

POPULAR SCIENCE

Your RIDE TO SPACE Is Ready

Radical, Cheap Design Is Built & Now Testing

ARE THEY NUTS?
Skydiving In A Flying-Squirrel Jumpsuit



[Plus] **ULTRA SLO-MO MOVIES**
SEE WHAT HAPPENS IN ONE 200-MILLIONTH OF A SECOND



Burt Rutan's hybrid-fuel SpaceShipOne rocket after separating from the carrier craft

US \$3.99 CAN \$4.75
JULY 2003

popsci.com

07>





THE NISSAN ALTIMA



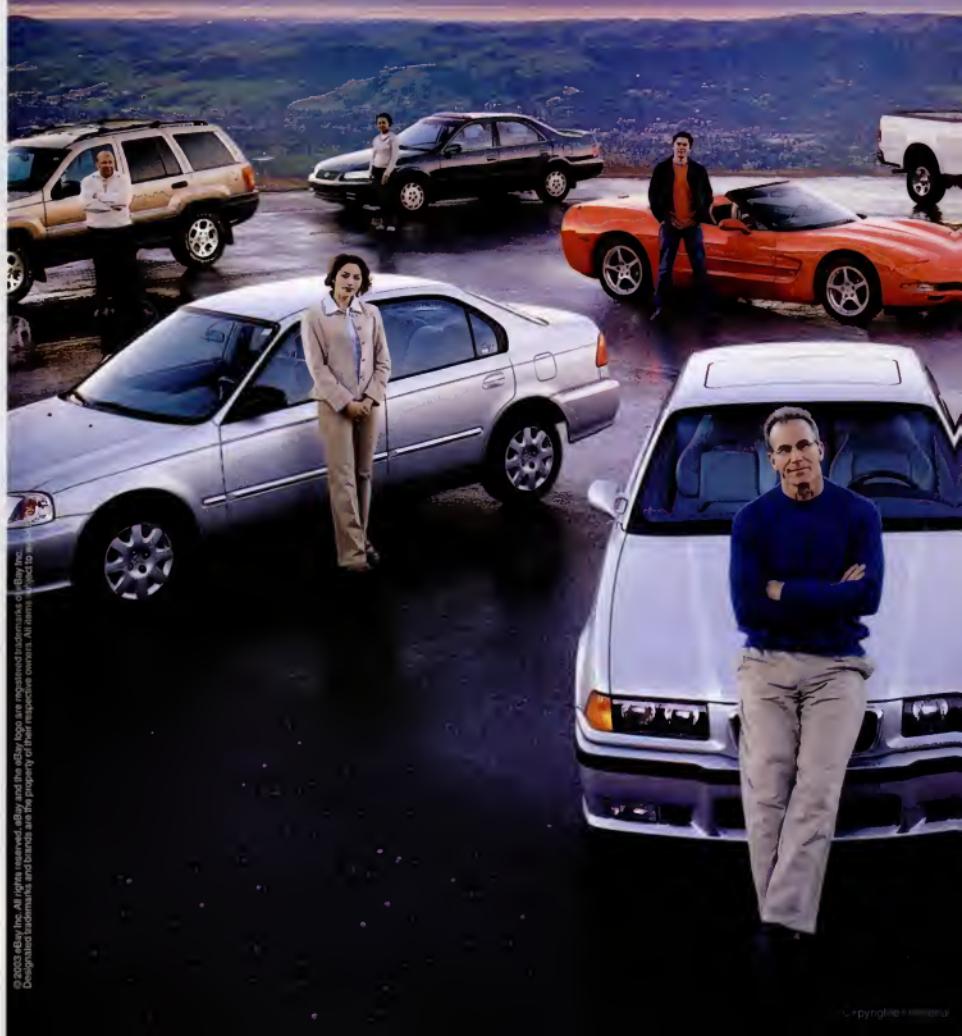
This One



BBYW-XJ5-D5KZ

That new car smell is overrated

And you'd much rather savor the scent of money
Even if you aren't the type to clip coupons or buy in bulk
Because nobody likes paying more than they have to
And finding a great deal is easy if you know where to look



© 2003 eBay Inc. All rights reserved. eBay and the eBay logo are registered trademarks of eBay Inc.
Designated trademarks and brands are the property of their respective owners. All items are subject to



Here's why hundreds of thousands of people buy and sell cars on eBay Motors.

 With nationwide selection on thousands of listings, it's easy to find more value for your dollar. Buyers are never charged fees to purchase on eBay Motors.

 You'll be safer when buying a car on eBay Motors. Most used car transactions are insured to protect against fraud up to \$20,000, at no additional cost to the buyer.

 Most used cars under 10 years old with fewer than 125,000 miles are covered by a 30-day/1,000 mile limited powertrain warranty, also at no additional cost.

 Be sure the car you're buying has a clean title history with available vehicle history reports. Simply click on the Vehicle Identification Number that's in most car listings.

 Every user on eBay Motors has a feedback rating. This rating is based on past transactions and helps buyers and sellers know who they are dealing with.

For information on warranty and insurance restrictions, visit ebaymotors.com

Do it 

IT WILL DRILL THROUGH WOOD, CONCRETE AND TIME.

Scared to go into the basement? Is it only fit for habitation by cardboard boxes, cobwebs and the outdated washer and dryer? Obviously, you need to do something about it. If only there were time right? Well, here's a way to find some. First off

you'll need materials: wood, drywall or wood paneling and hardware—screws and bolts. And then, you'll need a drill with the power to turn your dungeon of despair back into a living space. Volt for volt and feature for feature, no line of cordless drills offers more torque than our new Craftsman EX drills. With a bigger motor, these drills will carve right into stone or concrete. The built-in level will make sure

SEARS

your pilot holes stay on the straight and narrow, too. But anyone who has worked with concrete or stone foundations will tell you, it doesn't give up easy. No, far from it. But that's okay. The cushioned pistol grip dampens the vibration caused by drilling

through substances. In other words, the walls will hold long before your hand will. Speaking of going up, you'll be a long way into drywall or wood paneling to the studs before the

Introducing our new line of EX cordless drills. Extra torque. Extended run time. Extra performance.



EX wears out. Every EX drill has the longest battery life of any drill in its class. Longer time working and less time changing batteries. And when you think that for every sheet of drywall you'll be driving four rows of five screws, the EX can save you a lot of time. Which brings us to the final point. What are you going to do with all the time you just saved? Perhaps spend it in your now newly renovated basement, excuse us, family room watching the game? The new line of Craftsman EX drills. Find them at Sears, Sears Hardware Stores, online at craftsman.com or call 800-437-9686. You'll find it well worth your time.

CRAFTSMAN

MAKES ANYTHING POSSIBLE®

POPULAR SCIENCE

Founded in 1872

tech**11 What's New**

The high-end audio evolution; Volvo's new concept car; Herman Miller's latest office chair, the Mirra

news**37 Headlines**

SARS Tracking the origins ON THE BIKE
Lance's tech CLONING Copy endangered species? ROBOTS Germany's sewer snake

● stories**46 Burt Builds Your Ride to Space**

The man, flight plan and revolutionary design behind SpaceShipOne.

By Bill Sweetman

IN THE SPIRIT OF THE WRIGHT BROTHERS,
1903-2003

54 The Flight of the Bird Men

Two skydivers reinvent a risky, winged flying suit, and revive a dream.
By William Speed Weed

62 Red Planet Blues Post-Columbia,

a Mars mission seems even more daunting. Here are the challenges NASA is facing. By James Oberg

72 Lights, Camera, Nanosecond

Action 20 million frames in the blink of an eye: a look at the world in super slo-mo. By Ethan Smith

adventure**89 PopSci Adventure**

FIRST PERSON Extreme free diving

GRAY MATTER Liquid nitrogen ice cream

depts.**6 From the Editor 8 Letters 28 Man &**

Machine 32 Crime Seen 96 FYI

116 Looking Back

"You're stepping into the complete unknown. You have to commit everything you ever knew. I gave myself a 50-50 chance."

[THE HISTORY OF THE MOON](#) p. 54



11



46



72



82



89



62



92



26



Mars is Not a Money Issue

WHENEVER THIS MAGAZINE RUNS AN ARTICLE SUCH AS "Red Planet Blues" (p. 62) or "Go Somewhere!" (April 2002) we receive letters protesting that our interest in a Mars mission is misguided. A Mars mission, the argument goes, will squander tens of billions of dollars better spent on problems here on Earth. This is a hopeful but unconvincing argument. It assumes that money not spent by Washington on one thing will be intelligently diverted to another, more important thing. It assumes proportionality in matters budgetary. Call me cynical, but that is not my understanding of the horse trading and porkbarreling that passes for money-minding on Capitol Hill. To consider just one example of the stark contrasts in our spending habits: This is a country that found a way to spend north of \$1 billion *per airplane* on the admittedly awesome B2 bomber, yet beats its chest about allocating \$2 billion in 2004 to help 30 million people who are infected with AIDS in Africa. The United States is so wealthy (if not always so wise with its money) that it's hard to believe a full-tilt Mars mission, even one costing a hundred billion dollars or more over 20 years, would distort the massive budget—or prevent us from Doing the Right Thing.

No, money isn't the issue. The problem (odd, given our global military supremacy) may be a weakened sense of relevance to human history. Surely it's a good bet that manned exploration of the solar system (and beyond) will happen sooner or later. Therefore the question facing any given generation is whether it will decide to move the ball down the field or sit on the bench. The Apollo generation made one decision; this generation may be in the process of slumping its way into another. Yes, the race to the Moon was induced by Sputnik anxiety; it's trickier for the sole remaining superpower to find the will to get up for the game. But excuses won't make a failure to do so any less of a failure. As "Red Planet Blues" makes clear, the barriers to a successful Mars mission are daunting; it could take two generations of steady scientific work to overcome them. That sounds like fun. Let's get started. Who else will do the job?

SCOTT MOWBRAY
scott.mowbray@time4.com

POPULAR SCIENCE

Editor-in-Chief Scott Mowbray

Deputy Editor Mark Janot

Design Director Dirk Barnett

Executive Editor Vince Belski

Features Editor Emily Loker

Science Editor Dawn Stover

Technology Editor Suzanne Kantra, Kirschner

Managing Editor Jim C. Gorman

Associate Editor Michael Meyer

Associate Editor, Aviation & Military Eric Adams

Associate Editor, Life Sciences Rebecca Skloot

Associate Editor, Science News Nicole Dyer

Associate Editor, Who's New Sam Grabar

Assistant Editors Jenny Everett, Martha Harbison, Gregory More, Trevor Thieme

Deputy Art Director Hylah Hill

Assistant Art Director Jack McBride

Designer Neil Russo

Photo Editor Kristine LaMarra

Staff Photographer John B. Carnett

Editorial Assistant Barbara Carther

Web Producer Peter Noah

Consulting Editor Jeffrey Rothfeder

Graphics Consultant John Grimeade

Contributing Design Editor Chee Pearman

Contributing Automotive Editors Dan Sherman, Stephan Wilkinson

For East Contributing Editor Dennis Normile

Contributing Editors Don Carey, Robert Gannan, Bill Sweetman, Charles Wardell

Contributing Futurist Andrew Zolli

Contributing Artists Mika Grondahl, Jason Lee, John MacNeill, Gary Marshall, Stephen Raunert, Bob Saul

Art Intern Marina Grinshpan

POPULAR SCIENCE PROPERTIES

Publishing Director Denise Alderman

Director of Sales & Marketing Gregg R. Hana

Vice President & General Manager Steve Belanger

Northeast Advertising Office: Manager Jill Schiffman [212] 779-5007, Howard S. Millman, Steve Sigler

[212] 779-5252, **Ad Assistant**: Brenda Charles

Midwest Advertising Office: Manager John Margiandola [312] 640-3550, Andrew Cooper [312] 640-3552,

Ad Assistant: Mickey Preston

Los Angeles Advertising Office: Manager Dana Hess [310] 315-4380, **Ad Assistant**: Deena Hancock

Detroit Advertising Office: Manager Donna Christensen [248] 988-7723, **Ad Assistant**: Earline White;

San Francisco Advertising Office: Manager Amy Cicciolore [415] 434-5276, **Ad Assistant**: Sarah Needlemen; **Southern Regional Advertising Office:**

Manager: Dave Hony [404] 364-4090,

Classified Advertising Sales: Joan Orlitz [212] 779-5555

Business Manager: Jacqueline L. Pappas

Director of Brand & Business Development: L. Dennett

Rosenberg

Sales Development Director: David Farber

Marketing Services Manager: Melissa Kearns

Merchandising Manager: Daniel Vaughan

Promotion Manager: Christy Chapin Ellinger

Marketing Assistant: Estanda Coratway

Executive Assistant: Liz Johnson

Advertising Coordinator: Evelyn Negran

Vice President & Consumer Marketing Director: Cindy Still

Associate Circulation Director: Barbara Venturilli

Senior Planning Manager: Margerita Catwell

Director of Retail Sales: Robert Conigliaro

Senior Production Director: Laurel Kurnick

Production Assistant: Shawn Gleann

Presses Director: Lisa Szyniszak

Presses Manager: Jose Medina

Publicity Manager: Sara Deleka



President Mark P. Ford

Senior Vice Presidents James F. Else, Victor M. Sauerhoff, Steven Shure

Director, Corporate Communications: Robin Shallow

SUBSCRIPTION INQUIRIES

For subscription or delivery problems, or change of address, please call 800-289-9399

Some people see a brilliant star reasserting his dominance.



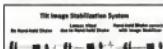
We see 32 of our lenses dominating a tennis match.

Those distinctive white lenses. Canon's unrivaled collection of over 50 EF lenses are everywhere serious photographers work. Especially our trademark white ones. That's because, quite simply, they're the world's most advanced lenses for the world's most advanced cameras, analog or digital.

Advanced Optics. Canon pioneered Aspherical Lens technology for SLRs, to correct conventional spherical lens distortion. The result is high contrast and resolution with minimal flare, even with large-aperture lenses. We also tackled the problem of chromatic diffraction. To that end, we created lenses of crystalline fluorite and super UD glass, which required

entirely new production technologies. In addition, Canon created unique Diffractive Optics lenses, like the EF 400mm f/4 DO IS USM. These lenses boast higher image quality, even with reduced size and weight.

Image Stabilization. Canon's exclusive Image Stabilizer lenses correct camera shake significantly.



In fact, they increase usable shutter speed range by up to a remarkable 3 full stops for hand-held shooting.

Ultrasonic Motor. To create the world's first lens-based autofocus drive motor, we had to first create a whole new technology:

ultrasonic oscillation, that gives you outstanding speed and precision in addition to near-silent operation.

So whether you happen to be using a Canon 35mm camera, or one of our digital SLRs, you can understand why Canon EF lenses are always the focus of attention.



Canon KNOW HOW™

A War on War Drugs

I wasn't surprised by your article regarding the use of pyridostigmine bromide by U.S. troops ["Soldier Meds: Are They Safe?" Headlines, May]. Despite FDA approval, research centers across the United States have shown that PB causes permanent side effects in animals. I'm also not surprised to learn that the U.S. military is mandating its use.

I was discharged from the Marines in 1999 for refusing an anthrax vaccination that was also FDA-approved. That vaccine, like PB, was being applied in a non-specific way: It was developed to prevent the spread of cutaneous anthrax to farmers from cattle, *not* for the anthrax strain typically used as a biological agent. No doubt PB will be recalled after too many servicemen and women complain it causes disabilities, just like the anthrax vaccine—and numerous others that haven't made it to your pages.

*Larry Averitt
Orange County, Calif.*

PB has been given to more than 250,000 soldiers, and nothing more severe than fatigue, memory loss and joint pain—side effects I'm sure any soldier would gladly endure in order to stay alive—has been reported. We should continue to administer

to soldiers drugs that we have reason to believe could be beneficial. If our enemies use chemical or biological weapons, we will be glad we did.

*Lemmy Reginaragh
Burke, Va.*

BIGGEST, BADDEST: SAFEST?

Anyone who has recently driven on our country's highways or parked at a shopping mall could have observed that the American motorist appears to be in a race to obtain the biggest, baddest vehicle. The reasoning seems based on the idea that "bigger is safer"

CORRECTION

While Mars Pathfinder was the first unmanned rover deployed on another planet ("Red Rover, Red Rover," May), it was not the first to successfully explore our solar system: The Soviet Union sent two unmanned rovers to the Moon in the early 1970s.



if you are involved in an accident. The perception is widespread. As pointed out in the article "Crash First, Ask Questions Later" [POPULAR SCIENCE Adventure, May], a smaller car suffers more damage than a larger car in a crash between the two, which reinforces the perception.

The issue that needs to be addressed and resolved is whether a larger vehicle provides more passenger safety when involved in a crash with a vehicle of *equal size*. Is a person safer in a Ford Explorer that is involved in a crash with another Explorer than he would be in a Toyota Corolla that's involved in a crash with another Corolla?

*K. Bahr
Gainesville, Fla.*

We Brake for Compliments

I wish to congratulate you on your article "My 1,500-Horsepower Brake Job" [Man & Machine, May]. I have read many articles on brakes, but never one written with the approach your author took. Many auto magazines have skewered, sectioned, filleted, and revised, but have never explained the topic with such ease. This should be required reading for all neophytes in the auto-crafting field; it wouldn't hurt well-versed vets to peruse it either.

*Bud Brinkley
Richmond, Va.*

POPULAR SCIENCE

HOW TO CONTACT US
Address: 2 Park Ave.,
New York, NY 10016
Fax: 212-779-5103

LETTERS
Comments may be edited for space and clarity. Please include your address and a daytime phone number. We regret that we cannot answer unpublished letters.
E-mail: letters@popsci.com

QUESTIONS FOR FYI
We answer your science questions in our FYI section. We regret that only letters concerned for publication can be answered.
E-mail FYI questions to:
fyi@popsci.com

PRODUCT INQUIRIES
E-mail: reader@popsci.com

POPULAR SCIENCE ONLINE
Visit our World Wide Web site at:
www.popsci.com
Or check us out on AOL at:
keyword: popsci

NEW SUBSCRIPTIONS
To subscribe to POPULAR SCIENCE, please contact:
www.popsci.com/subscribe
Phone: 800-289-9399

SUBSCRIPTION INQUIRIES
For subscription or delivery problems, or to report a change of address, please contact:
Popular Science
P.O. Box 40001
Tampa, FL 33660-0001
Phone: 800-289-9399
Web: www.popsci.com/manage

LUTRON DIMMERS SAVE ENERGY.

DIM YOUR LIGHTS TO SAVE ON YOUR ELECTRIC BILL AND MAKE YOUR BULBS LAST YEARS LONGER.



INSTALL A LUTRON DIMMER IN 15 MINUTES TODAY AND SEE THE DIFFERENCE TONIGHT.

Lutron dimmers are available at lighting showrooms, home improvement centers
or from your electrical professional.

For more information call 1-877-2LUTRON, Ext. 650 or visit www.lutron.com/popularscience

© 2001 Lutron Electronics Co., Inc.



LUTRON
Innovations in Lighting Control

DIMMER SHOWN IS
SKYLARK® MODEL S-600-WH



Protect his habitat. And yours.



Drop off your rechargeable batteries at the following national retailers:

In the US:
Best Buy
Black & Decker
Circuit City
The Home Depot
RadioShack
Sears
Staples
Target
Wal-Mart

In Canada:
Bell Mobility
Canadian Tire
Future Shop
The Home Depot
Motorola Cellular
Dealers
RadioShack
Sears
The Sony Store
TELUS Mobility

What does a pileated woodpecker and a cordless drill battery have in common? When you recycle your rechargeable batteries, you preserve his environment — and ours. Check the batteries in your other cordless power tools, as well as laptop computers, cordless and cell phones, PDAs, camcorders, and remote control toys. If they no longer hold a charge, recycle them by visiting www.rbrc.org/ps, calling 1-800-8-BATTERY, or dropping them off at one of these national retailers.

RBRC was named "Environmental Partner of the Year" by The Home Depot in 2002.

Recycle your rechargeable batteries.



RBRC Spokesperson Richard Kam,
"Al" from TV's *Home Improvement*

What's New

NOW HEAR THIS

HOT AUDIO TECH, FROM CD PLAYERS TO HEADSETS, GETS A FINE TUNING.

Audio components with breakthrough technologies don't always blow away audiophiles the first time around. Often, next-gen products need to be rethought—or at least seriously tweaked—to avoid an early death. (Did you mourn the passing of the Digital Compact Cassette? Didn't think so.) The products featured here have learned that lesson. To wit: The first Super Audio CD players were technologically advanced, but since many audiophiles (the kind of people to whom SACD was originally marketed) consider analog to be a softer sound in comparison to harsher digital tones, we are now seeing SACD players, like Shanling's SCD-T200. [CONTINUED]



DIGITAL PLAYER GOES TUBULAR

The SCD-T200 (\$2,695) features Sony's Super Audio

CD guts, but Shanling, a rather obscure Chinese electronics company, is the first

to add tube outputs to an SACD player (its previous model played only standard CDs). The result is a warmer and rounder sound. But tubes don't handle high-end frequencies very well, and there's no digital output.

(CONTINUED FROM PAGE 11)

that use old-style vacuum tube amplifiers. The in-car MP3 player has undergone its own evolution as well: While the original version was a nice idea, the process of downloading files into the trunk of your car was less than convenient—that is until Rockford decided to incorporate Wi-Fi. Now you can effortlessly transmit tunes stored on the computer in your home office directly to your car. On these pages we highlight a range of audio products that have gone through this natural maturation process—the kind of process that takes really good ideas and turns out even better products. Of course, the work is never done—in coming months expect to see MP3 players tripling storage capacity as well as SACD and DVD-Audio for your car.—SUSANNE KANTHA KIRSCHNER

SPEAKERS PLAY
FOR HANG TIME

1

If you've got the 50-inch plasma, you don't want to ruin its lines with monster speakers. That's why Final separated out the electronics, making the Model 100 (28.1 by 7.9 by 1.6 inches) the first truly wall-mountable electrostatic speakers. (The bulky electronics reside in an easy-to-stash box.) What's more, a new audio transformer brings the power requirements down to 60 watts, so the Model 100 (\$1,999 per pair) can be used with mid-priced receivers. Fortunately, the Model 100's design isn't its only selling point: The speakers sound as good as they look.

AMPLIFIER OPTS FOR
MILITARY POWER

2

Why buy a \$6,000 integrated amplifier? Because Musical Fidelity's Tri-Vista 300 integrated amp delivers a whopping 350 watts per channel. Other amplifiers have this kind of wallop, but none do it with Tri-Vista's new military spec vacuum tube, the 5703.

The tube, developed to work in place of solid-state electronics in the event of a nuclear detonation, delivers extremely reliable power; but even if you don't use all that wattage, you'll appreciate the almost tactile sound. The design is so high-tech you might think it came from a skunk works: Turn it on and the amp's feet glow red, then orange and finally blue when the unit is ready to go.

3 FLABBY HEADPHONES SHAPE UP

Bose's first-generation noise-reducing headphones worked well, but the pack-of-Marlboros-sized external power source made you feel like you were wearing a heart monitor. Fortunately, Bose went back to the drawing board and, by using some miniaturized chips, capacitors and resistors along with some clever engineering, managed to cram the parts into the earpieces of its QuietComfort 2 (\$299) headphones. Others have tried the squeeze play before, but sound quality suffered considerably. Bose pulls off the miniaturization trick without losing a note.

4 LITTLE JUKE'S PLAYLIST GROWS

Until now, MP3 players came in two basic types: There are the truly pocket-sized players, like the Samsung Yp-30SH, which hold only a paltry hour or so of music—barely enough for the morning commute; and the 10 to 30GB pocket rippers, like the iPod, which store weeks of music. RCA's Lyra Micro Jukebox (\$249) begins to close the gap. At 2.2 by 2.2 by .9 inches, it's small like a pocket player, but its 1.5GB of storage can carry 25 hours, or 500 songs. A 1-inch magnetic disk developed by Cornice enabled RCA to shrink the device while maintaining a low price. Now, if it only had the iPod's easy user interface.

5 AUTO PLAYER SHIFTS INTO WI-FI

In-car MP3 players seem cutting-edge—until you have to transfer music to them. Open the trunk, remove the hard drive, bring it to your PC for a sync, then put it back in the trunk. Rockford Fosgate's Omnitri system (\$599) automatically synchronizes with your desktop PC via a WiFi antenna (\$99) when your car is within 300 feet of it. One drawback: the extra head unit you have to mount somewhere on the dash.







ZERO TO "I'LL TAKE IT" IN FIVE SECONDS.

The Impala® LS Sport Appearance Package. It'll take you all of five seconds to decide you absolutely love its sporty looks, plus the awesome power of its 200-hp 3800 V6 engine. And that includes two seconds to figure out how you're going to explain buying it to your significant other. chevy.com or 1-800-950-CHEV

IMPALA  **WE'LL BE THERE**

Best Seat in the Office

If the Aeron busts your budget, try Herman Miller's simpler eco-friendly Mirra.

Four years ago, Herman Miller assigned Studio 7.5, a Berlin-based design outfit, what seemed like mission impossible: Create a chair that's as comfortable and stylish as the groundbreaking Aeron, but much simpler to use and more affordable. Oh: it must be ecologically sensitive too. "We had to reinvent every part of the chair," says designer Burkhard Schmitz. "The challenge was to make it as simple as possible yet very adjustable. It took a huge effort." It paid off. We found that the new Mirra (\$640) contours nicely to your body, adjusts easily enough, and pleases the eye too. The PVC-free chair—armrests and internal cables typically contain this toxin-filled polymer; the Mirra uses thermoplastic elastomer—is made of 42 percent recycled materials and is 96 percent recyclable or reusable. Below, four key design innovations that'll leave you sitting pretty.—JENNY EVERETT

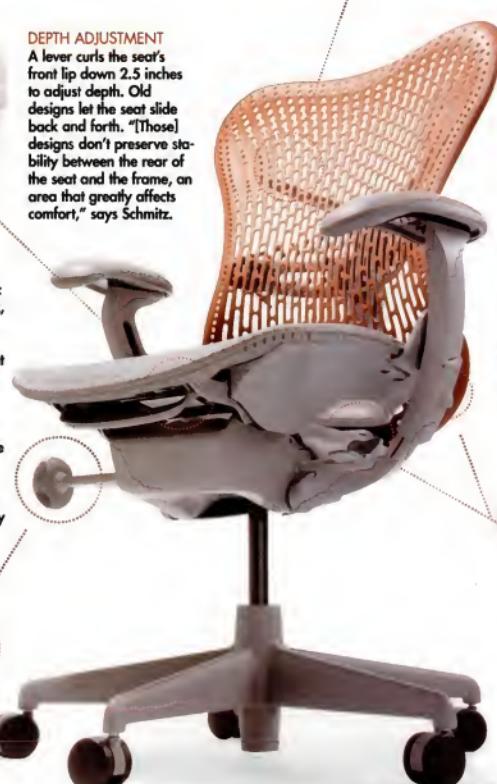


DEPTH ADJUSTMENT

A lever curls the seat's front lip down 2.5 inches to adjust depth. Old designs let the seat slide back and forth. "[Those] designs don't preserve stability between the rear of the seat and the frame, an area that greatly affects comfort," says Schmitz.

RECLINE ASSIST

Most chairs use a coil spring to control reclining: The further you lean back, the tighter the spring gets and the more force you need to apply. Lightweight people in particular have a hard time with this design. The Mirra's innovative leaf-spring system uses a knob to change the fulcrum under the seat, altering the responsiveness of the tilt. The result: an effortless recline to any position for any user.



BACK SUPPORT

The seatback, made of PVC-alternative polypropylene, contains 567 holes, each with a unique shape. This allows the seatback to flex differently in three separate zones to offer more or less support to the appropriate part of your back. The holes also provide ventilation. "The beauty here is the absence of material," Schmitz says.

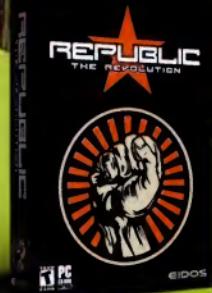
TILT CONTROL

The Mirra's seat and seat back tilt independently—a nice touch—and do so with a lever in the shape of the chair itself, making the process much more intuitive than the Aeron's. The seat adjusts forward and back, while the seat back can swing freely or lock from 4 degrees forward to 26 degrees reclined. The armrests adjust independently.



He has the right
power to play
this game.

Do you?



Equip your PC with the power of NVIDIA GeForce FX.

To become the choice of the people in the award-winning PC game, *Republic: The Revolution*, you'll want to possess the choice of PC gamers—the NVIDIA® GeForce™ graphics processor. Ok, you can also use charisma, vision and ambition to boot. But to experience life-like characters and cinematic graphics at blazing speeds, you'll want to equip your PC with the performance, compatibility, and reliability of the NVIDIA GeForce FX GPU. After all, today's hottest games, like *Republic: The Revolution*, are developed on NVIDIA, to be played on NVIDIA. So if you want to play this game the way it's meant to be played, equip your PC with an NVIDIA GeForce FX GPU.

Look for this seal on games like *Republic: The Revolution* and PC hardware equipped with an NVIDIA GeForce FX GPU for the ultimate "install-and-play" experience.



VOLVO TURNS A CORNER

THE SWEDISH AUTOMAKER DITCHES THE RESPONSIBLE AND SENSIBLE FOR THE RADICAL, SYBARITIC AND . . . SENSIBLE.

Volvo's Versatility Concept Car (VCC) offers up Benz-level luxury, but has the good Scandinavian sense to temper it with some solid eco-friendly technology. Let's get the luxury out of the way first: Seats padded with form-fitting Tempurfoam and covered in thick Hovana hide (Volvo's term), wireless touchscreen multimedia displays for each passenger, and rear storage compartments that can be heated or chilled till the VCC into a rolling Ritz-Carlton. Fuel efficiency, however, is also a priority: When the VCC stops moving, say, at a stoplight, its 250-hp turbocharged 6-cylinder engine turns itself off; it restarts immediately and imperceptibly when your foot hits the accelerator. The engine also shuts down in slow traffic, allowing a 42-volt battery-powered electric motor to move the car. The electric drive motor assists the engine at low revs while the turbocharger is reaching the necessary boost level, and replaces torque lost while the transmission is switching gears.

In addition to sending fewer pollutants into the air, the VCC helps nullify other cars' emissions. When a sensor detects excessive outside pollution, the air is routed through two filters that trap hydrocarbons and nitrogen oxides before they are sent into the cabin. The pollutants are eventually dumped into the engine, where hydrocarbons burn within the cylinders; the catalytic converter reduces the nitrogen oxides. The sensor operates 24 hours a day, and a roof-mounted solar panel powers a fan that moves air through the filters even when the car is parked, allowing the VCC to absorb emissions from other vehicles. Leave it to the Swedes to dream up a car that's good for its owner and the neighborhood too. —SAM GROBART

Wagons Ho: First was Audi's Avantissimo, then Mercedes-Benz's GST; now it's Volvo's turn to show off their Wagon of the Future. Should the VCC make it to production, Volvo admits these suicide doors won't.



2



3

1] The V-Pulse is no ordinary keyless entry fob that merely locks and unlocks your doors; it also maintains a constant data link with your vehicle. When all is well, it gently pulses in your pocket. Should something go wrong while you're away (e.g., the alarm goes off), the device pulses more rapidly and a display tells you exactly what's happening. When in the car, place the V-Pulse into a console-mounted cradle and press it to start the engine.

2] Eschewing CDs and DVDs, the VCC provides entertainment using a wireless connection to your home network. Touch-sensitive screens for each passenger access music, movies, the Internet and navigation data.

3] Underneath the rear cargo area are two temperature-controlled bins for your meals on wheels. One bin is refrigerated to keep foods chilled, while the other uses engine heat to keep its contents warm.

4] The transparent roof features a solar panel to power the constantly running air purification system. The roof also houses the cabin's ambient lighting, which is operated by slider controls in the overhead console.



4

Goods to Go

Don't just pack light, pack smart.

Small and light gadgets can make a journey easier, but sometimes performance and features get squeezed out in the bargain. What we have here are tech toys for vacationing that are among the smallest and most versatile in their classes, like the tiny 3-megapixel Nikon (shown) which helps you compose even the toughest travel shots. The priorities are the same for luggage: You want innovations to ease the schlep—because it's not a real vacation if you don't buy a lot of cool stuff to cram into your suitcase for the trip home.—JENNY EVERETT



TAKE WINDOWS WITH YOU

This tri-band GSM cellphone from HTC is the first globe-trotter to incorporate Microsoft's Windows-esque Smartphone platform. The Orange SPV phone was launched in Europe last fall. The first U.S. version of the Smartphone, Samsung's small clamshell SCH-i600, (no price set) is expected by year's end.



ARRIVE ON TIME

Oakley's GMT wristwatch (\$575 to \$650) tracks time in all 24 time zones: Just point the big red hand to a location indicated on the rim of the watch face, and one of the small dials tells you the time. One drawback: It's mighty heavy. www.oakley.com



PACK A TRAVEL MATE

The svelte (.67-inch deep) Palm Zire 71 (\$299) has a 16-bit, 320- by 320-pixel color screen—perfect for map reading. The PDA's 640- by 480-pixel (VGA) digital camera has a long shutter lag, and there's no flash included, but the camera captures decent images when on the run. www.palm.com/zire71



COMPOSE YOUR VACATION

The Coolpix 3100's (\$350) four Scene Assist modes suggest the best composition for 14 possible scenarios—from sporting events to portraits to architecture. Simply frame your subject within the lines on the display, press the shutter button, and you can't go wrong. www.nikonusa.com/coolpix



MAKE THE LONG HAUL EASY

Flip a lever on Swiss Army's Triax roller (\$499 to \$679), and the interior expands 3 inches. Nearly indestructible, the Triax is made of the Kevlar blends used in motorcycle apparel and bulletproof vests. And the handle rotates in three directions to accommodate ergonomic hand positions. www.swissarmy.com



SMOKER?

- ☞ Get 80% less secondhand smoke.
- ☞ Get no lingering odor.
- ☞ Get a special introductory offer.
- ☞ Get online.

If you want to know, you've got to go.

www.newcig.com



Not available everywhere.
Log on to find a store near you and to
get a special introductory offer.



SURGEON GENERAL'S WARNING: Smoking By Pregnant Women May Result in Fetal Injury, Premature Birth, And Low Birth Weight.

Brought to you by  R.J. Reynolds

Offer and website restricted to smokers 21+.



Hotels Check In New Tech Services

Coming Soon: Wi-Fi, plasma displays, and videophones.

A few years from now, your vacation might take you to a room much like number 267 at the Hilton Garden Inn at LAX/El Segundo. As you enter, motion sensors automatically turn on the lights. You touch the biometric safe with your thumb, and the door opens to store your valuables. You flop on the bed, and its system of slats and air pockets molds to your body's weight and contours. Your remote dims the lights, opens the drapes, checks your e-mail on plasma television, and changes the digital artwork on the walls to suit your tastes. A videophone lets you see that it's room service knocking at the door with a chilled bottle of champagne. Not a bad way to start your vacation.

Room 267 is Hilton's test lab, but it won't be long before at least some of these innovations become standard fare for large hotel chains. "In 10 years, hotel rooms will look nothing like they do today," says Dennis Koci, senior vice president of operations support at Hilton Hotels. "For instance, walls will be entertainment portals, where any mood or multimedia experience is possible."

Why the hotel tech frenzy? Well, primarily because demand is growing and tech is becoming more affordable. Take Wi-Fi, for example—it costs less to install than fiber optic cable, which entails running thousands of yards of wire. Since December Marriott International has Wi-Fi-enabled close to 400 of its Marriott, Renaissance and other properties. Both Storwood and Hilton are racing to provide wireless service too. The Hotel Valencia in Silicon Valley, with help from Hewlett Packard and Cisco, now offers wireless access and Internet-capable Cisco phones in the guestrooms. Travelers can expect to pay \$10 to 20 per day for the hookup, which hoteliers hope will appeal to both business people and families. If you are going to browse the Web, you might as well be poolside.—JOANNE RAMOS

TECH TRAVEL TIPS

1 INFLIGHT IM

For \$5.99 per flight, Verizon Airfone's JetConnect (on Continental Airlines) hooks to a laptop or PDA to offer instant messaging, news, stock quotes, local listings and games. www.verizon.com/airfone/jetconnect

2 WORLD IN YOUR PALM

MobiMate's WorldMate PDA software (\$24.95) checks the time in five cities in a flash, calls up the weather forecast for each city, and converts nearly 100 world currencies. If your PDA is wireless, WorldMate can update itself on the road. www.mobimate.com

3 DISPOSABLE CELLS

Hop-On's new disposable, recyclable, prepaid mobile phone (with coast-to-coast coverage) offers 60 prepaid minutes for \$40. www.hop-on.com

4 COMPACT CO-PILOT

Mapopolis' Clear Route package (\$349.99) uses a GPS transmitter with your Pocket PC to determine your car's position and speed, and suggests alternate routes to avoid traffic. www.mapopolis.com

—EMILY BOBROW



SOONER OR LATER

YOU'LL BREAK DOWN
AND BUY ONE.

V STAR 1100
SILVERADO



The V Star is not only one of the most jaw-dropping beautiful cruisers on the road today - it features the rock-solid reliability Yamaha is known for. So no matter which of the six models you choose you'll be cruising in style for years to come.



YAMAHA

Special thanks to Judy Davis, Mike Pace and to all the STAR members of Chapter 123 who helped in the making of this ad.

Dress properly for your ride with a helmet, eye protection, long-sleeved shirt, long trousers, gloves and boots. Yamaha and the Motorcycle Safety Foundation encourage you to ride safely and respect the environment. For further information regarding the MSF rider course, please call 1-800-446-9227. Do not drink and ride. It is illegal and dangerous. ©2002 Yamaha Motor Corp., U.S.A. Cypress, CA 90630

For the Yamaha dealer nearest you call: 1-800-88-YAMAHA yamaha-motor.com

DIESEL SALES IN EUROPE POWER INTO HIGH GEAR

Credit modern common-rail diesel engines—which don't smell, don't click, and aren't anemic—for diesel's European renaissance. Fuel also costs four times as much in Europe, so diesel's efficiency has wider appeal there. U.S. emission laws have been no friend to oil-burners (they put out more soot than gasoline-based engines), though VW has been selling diesels here since 1996, and Mercedes-Benz will introduce a new diesel E-class this fall.

DIESEL SALES (AS A PERCENTAGE OF TOTAL PASSENGER CAR SALES)

COUNTRY	1992	2002
01] Austria	26.3	69.6
02] Belgium	31.7	64.2
03] France	39	63.2
04] Luxembourg	25	61.1
05] Spain	18.2	57.3
06] Italy	7.9	43.6
07] Germany	15	38
08] Portugal	7.7	34.4
09] UK	12.6	23.5
10] Netherlands	11.7	21.6
11] Denmark	3.1	20.2
12] Switzerland	2.8	17.8
13] Norway	9.6	17.5
14] Ireland	16.5	16.0
15] Finland	4.9	15.3
16] Sweden	0.9	7
17] Greece	1.6	4
Average	17.3	40.5



TEST DRIVE: HONDA FCX

The world's first limited-production fuel cell car just wants to blend in.

In April we got behind the wheel of the Honda FCX, the first fuel cell vehicle to receive U.S. government certification for road use. There was little about our 20-minute test drive that was extraordinary, and that's a compliment: We were impressed that Honda has managed to make a hydrogen-powered car that looks and rides much like the dependable Civic we all know and love.

Sure, there are differences: The three-door FCX is slightly taller than your average hatchback (to help accommodate the two large hydrogen tanks) and the FCX looks like any three-door you've ever met. The biggest difference we noticed was when we turned the key since the electric motor makes virtually no noise.



The streets of Manhattan require rapid acceleration and speedy maneuverability, and the FCX was hardly a slacker. Honda says the car puts out the equivalent of 80 horsepower, which isn't much, but the motor generates an impressive 201 pound-feet of torque. And since electric motors deliver maximum torque from the moment they're activated, the FCX handled just like a peppy four-banger. Some of this pep comes from the FCX's Ultra-capacitor, a rapid-discharge unit that stores power generated from the fuel cell and captured from braking.

The car's range is about 170 miles, though that could increase by 60 percent if Honda can improve the hydrogen compression from 5,000 psi to 10,000 psi. Of course, there's nowhere to refuel the FCX right now (the city of Los Angeles is the sole lessee of the five FCXs in this country). But should the infrastructure come into place (think decades, not years) a car like the FCX could succeed. From the driver's seat, it isn't all that different from anything on the road today.—SAM GROBART

SHARP.

37" Liquid Crystal Television

AQUOS™



be provocative



Screen image simulated. *Screen size measured diagonally. ©2003 Sharp Corporation

Introducing a television experience like no other. The AQUOS 37" Liquid Crystal TV.TM A masterpiece of design and technology that's a showpiece in any space. Unparalleled liquid crystal picture quality and long product life. Plus, low watt consumption means an environmentally friendly way to watch television. AQUOS by Sharp — Inspired design for the way you live. sharpusa.com



be sharpTM

©2003 Sharp Electronics Corporation

THE TICKER:

Coaxsys' Pure Speed (\$350) allows you to use your home's coax wiring for networking. It provides the same reliability and speed as Ethernet without installing new wires. » The universal DVD player/recorder is almost here. Next month Hitachi will unveil the first player recorder for DVD-R, DVD+R, DVD-RW, DVD+RW and DVD-RAM. » Yet another DVD standards war is brewing. The DVD Forum expects to release a new blue laser technology standard this year that will compete directly with the recently established Blu-ray Disc format. The new standard will quadruple DVD recording capacity and hold about 2 hours of HD programming on a disc. » Arison Entertainment is the first to deliver regular and HD versions of a movie on one DVD disc with its re-release of *Terminator 2: Judgment Day*. The HD version can be played back on PCs using Microsoft's Windows Media 9. » Logitech's Mobile Video service (\$5 per month) turns a Get It Now-enabled Verizon phone into a webcam viewer. The software provides a chatty, but viewable, one-way video stream. » Instant messaging needn't chain you to a PC with Matarolo's iMfree (\$99). Up to seven of these handheld wireless devices can communicate with your PC at one time, leaving it free for other family members. » Matarolo has also applied for a patent for a solar-powered phone display that would use light to illuminate the display and power the phone itself. » A considerably less bulky Segway prototype (shown) has been spotted rattling around on the streets of Manchester, New Hampshire. A tester, who refused to be identified, told us the prototype, called Metro, is more compact but less capable. Segway had no comment. » Audi's flagship sedan, the A8L, is equipped with a new sound system from Bose which reduces background noise. The stereo uses Bose's noise-cancellation technology, firing opposite-wave frequencies to cut down on unwanted sounds (for example, engine hum and tire roar) from the cabin.



A tester, who refused to be identified, told us the prototype, called Metro, is more compact but less capable. Segway had no comment. » Audi's flagship sedan, the A8L, is equipped with a new sound system from Bose which reduces background noise. The stereo uses Bose's noise-cancellation technology, firing opposite-wave frequencies to cut down on unwanted sounds (for example, engine hum and tire roar) from the cabin.



ALTERNATIVE CURRENTS: WI-FI FOR THE MASSES

Michael Oh's black Saturn coupe often sits outside a Boston Starbucks, but he's not craving a Frappuccino; Oh's chasing Wi-Fi users. He converted his coupe into a mobile Wi-Fi transmitter to offer free broadband access to people who would otherwise have to pay for it at places like Starbucks.

It's all perfectly legal, since Oh, who preaches that Wi-Fi should be free, uses his own homemade network. Other believers in free Wi-Fi have put chalk markings on buildings—called "war chalking"—to indicate Wi-Fi hotspots that people can tap with a laptop. Oh brings the bandwidth to the user. "The car is an incredible way of showing that wireless has no boundaries," he says.

Oh's Saturn is equipped with a six-foot Orinoco antenna on the roof and an Apple AirPort Base Station Wi-Fi node inside the rear window. The car receives high-speed Internet access beamed from a T1 line in his office as far as 1,500 feet away, and the AirPort creates a Wi-Fi bubble with a radius of about 150 feet. He attracts a handful of users at any one time, whether he's at the Boston Marathon or in front of a quiet office building.

When Oh isn't giving Wi-Fi away, he operates NewburyOpen.net, a wireless network covering much of Boston's eight-block Newbury Street shopping district (newburyopen.net offers detailed instructions on how to build a Wi-Fi car). Shops pay for the network as they believe free Wi-Fi will bring in more customers. The wireless business has apparently been good to Oh, who recently added a second vehicle to his Wi-Fi fleet: "We've upgraded to a Lexus IS300." —GREG MELVILLE

THE EIGHT FASTEST MOTORCYCLES OF 2003*

①	KAWASAKI NINJA ZX-12R	[1198cc]	186 MPH
②	SUZUKI GSX1300R HAYABUSA	[1298cc]	184 MPH
③	HONDA CBR1100XX	[1137cc]	177 MPH
④	SUZUKI GSX-R1000	[988cc]	177 MPH
⑤	HONDA RC51	[999cc]	171 MPH
⑥	KAWASAKI NINJA ZX-9R	[899cc]	169 MPH
⑦	KAWASAKI ZZ-R1200	[1164cc]	169 MPH
⑧	HONDA CBR954RR	[954cc]	168 MPH

* as tested by Cycle World

Available Allison
Transmission



BEST. BEST. BEST.

3 STRAIGHT YEARS, CAR AND DRIVER'S "BEST PICKUP"

As the saying goes, it doesn't get any better than this. Chevy® Silverado® has won CAR AND DRIVER's "Best Pickup" award for three straight years. In fact, Chevy is the only brand of pickup to ever win the title. Period. So what does it take to be the best?

TOUGH TECHNOLOGY.

Silverado technology is tough technology, designed to bring you a more dependable, longer-lasting truck. That's why Silverado was the first full-size pickup ever built with a hydroformed steel front frame – an innovation that makes our frame exceptionally tough, strong and durable.

And now, specific Silverado models are available with QUADRASTEER four-wheel steering, making Silverado with QUADRASTEER the most maneuverable full-size pickup you can get.* At highway speeds, the front and rear wheels turn in the same direction for added stability when passing or changing lanes while trailering.

LEGENDARY POWER.

The broad and powerful lineup of engines available in a Silverado is something CAR AND DRIVER always applauds, and who are we to argue? Silverado has six legendary Vortec® gas engines to choose from. The Vortec 8100 Big Block V8** cranks out a full 340 horses while the mighty Duramax™ Diesel** generates 300 horses and 520 lb.-ft. of torque to handle the biggest jobs.

BROAD RANGE OF MODELS.

Silverado isn't just one truck. It's a whole lineup of trucks that are precision-engineered and built to our high quality standards. Whether your Silverado is light-duty, heavy-duty, long box, short box, regular cab, extended cab, crew cab, two-wheel drive or 4x4, it can help you get the job done, and get it done right.

As CAR AND DRIVER's Best Pickup for 2001, 2002 and 2003, we didn't just set the benchmark. We built the bench. Silverado. The Truck. From Chevy. The most dependable, longest-lasting trucks on the road.**

SILVERADO **LIKE A ROCK**

877-THE TRUCK or chevy.com/silverado *Excludes other GM vehicles. †Available only on specially equipped 1500 Ext. Cab Short Box and 1500HD models. Call or go online for details. **Based on turning diameter. Excludes other GM vehicles. ‡Available only on 2500HD and 3500 models. ***Dependability based on longevity: 1981-July 2001 full-line light-duty truck company registrations. Excludes other GM divisions. QUADRASTEER is a trademark of Delphi Corporation. © 2003 GM Corp. Buckle up, America!

© 2003 GM Corp. Buckle up, America!

MAN & MACHINE

BY STEPHAN WILKINSON

HARD, FAST, SHINY OBJECTS &
WHY WE LOVE THEM

A Car Stereo That Can Kill You? Cool.

There may be no weirder tech-to-tech combat than the fight to build the world's most powerful sound system.

TROY IRVING'S 18-YEAR-OLD Dodge Caravan has a hell of a sound system: 72 amplifiers—you got it, 72—and 36 big 16-volt batteries to put out the 130,000 watts of power needed to rumble his nine 15-inch subwoofers. To put that into perspective, the most powerful production-car audio I know of is the \$230,000+ 2003 Aston Martin Vanquish's 1,200-watt system. Irving carries \$80,000 worth of audio alone, in a vehicle that is worth, admittedly, slightly less than the Maybach. Must be fun to ride down Main Street with the windows rolled down, right?

Not really. At a curb weight of about 10,000 pounds, the Caravan is basically undrivable. There is virtually no room for a driver, and even less for a passenger. "We need more batteries, but that's all the room we have," Irving gripes. But he can at least sit in his driveway and listen to music, yes? Actually, no. Irving's audio system can't play music. It's designed to play a single frequency—74 Hz—very loud. Irving, you see, is a dB drag racer.

dB (as in decibel) drag racing is an obscure but growing international "sport" in which competitors go head-to-head for two or three seconds at a time—hence the name drag racing—to establish whose sound system is loudest. The 2002 record, set by a German team of secretive audio engineers, was 177.6 dB.

The roar of a 747 on takeoff is usually quantified at about 140 decibels, although there's really no way to correlate the wide-spectrum noise of jet engines in open air with a low-frequency pure tone inside a highly



HIS IS WAY, WAY, WAY BIGGER THAN YOURS:
Troy Irving and his Dodge Caravan, which has 72
daisy-chained Ample Audio 1500 DX amps.

reflective enclosure. Because the decibel scale is logarithmic, with every 10 dB increase equivalent to a doubling of perceived sound (otherwise known as noise), dB drag racing enthusiasts create some seriously loud tones. (Another rule of thumb: All else being equal,

every three dB of increased sound from a typical dB drag racing system requires a doubling of amplifier power.)

Such noise would turn your brain to tofu if it weren't generated into uninhabited, tightly sealed space, such as the interior of a vintage Caravan. Com-



Photos and video at the same time.

Because “Can you do that again?” is probably not an option.

DIGIC
DV



Mac



Mini DV

Multi-tasking has never been easier. The new Canon Optura 20 is the world's first Mini DV that actually lets you shoot photos and video simultaneously. And Canon is the only company to develop an image processor that's optimized for both photos and video. DIGIC DV works like a brain, evaluating what you're shooting, then making adjustments, so the colors you see are the ones you get. Combine that with a Genuine Canon 16x

Optical Zoom lens and industry leading image stabilization, and you'll find that any other Mini DV is not an option. www.canondv.com



optura 20

Canon
KNOW HOW™

petitors in the Extreme class bolt doors shut. Irving uses industrial jig clamps and a threaded one-inch steel rod and nut through the window for extra security. Drag racers replace windows and windshields with Plexiglas up to two inches thick, secure panels with turn-buckles fit for an America's Cup racer and, in some cases, fill the doors with concrete. Then, while the tone burst is generated, team members lie spread-eagled on the roof and push against the car from the outside to bolster it that little extra bit. One Extreme competitor in search of ultimate stiffness used an armored truck, so we can expect to see Iraq-campaign M1A1 Abrams tanks doing sonic smoky burnouts as soon as they're declared surplus.

The sound that leaks out is pretty much what you hear when you inadvertently turn your home stereo on with the volume all the way up and a loose speaker wire: a rattling, destructive, marrow-fluttering hum.

Literally destructive. Many teams spend the time between runs repairing blown speaker cones, which is the dB drag racing equivalent of John Force's melted pistons. "These speakers are like funny-car engines," Irving says. "Some of those cars run for three or four seconds. That's what we design these for—very short bursts of extreme power. Run them down the road for 30 minutes playing music and they'll be useless." At the volumes dB racers run, speaker voice coil temperatures spike almost instantly, going as high as 500°F, and the sound deteriorates.

At the end of each major meet, the four loudest competitors line up for the "deathmatch," a five-minute, winner-take-all face-off in which they fire sound salvos at one another as judiciously yet loudly as possible, trying to keep their speakers and power sources alive until time is up. Amid the reek of ozone and melting metal, often just one is left standing. Only heavily sponsored competitors dare play this last game, since the cost in equipment is so high.

Many of the cars that performed at a dB drag racing event I attended in Toronto were sad-looking beaters, some with zoomy but faded paint jobs



NOISEMAKER: The interior, top, is designed to focus the sound from 9 Atomic Apocalypse X speakers on a single microphone; above left, exterior controls for the tape deck (CDs skip); above right, door clamps.

advertising their sponsors or owner's car-audio shop. A Super Street class Nissan Pulsar brush-painted a bilious green potted onto the judging ramp, driven by a kid sitting on a plastic milk crate. A jumble of amps, cables and batteries was barely visible through the dirty back window. Yet it blew away its bracket partner with a thunderous 158.2. "Cosmetics aren't going to make it any louder," says Extreme competitor Frankie Valenti.

Valenti was frazzled, having pulled an all-nighter trying to get his GMC van's "enclosure" right. The efficacy of the whole system is largely deter-

mined by the sharp-edged, multi-faceted shape inside the van—usually built of wood as much as 4 inches thick—with fiberglass covering what used to be the dashboard, center console, steering column and anything else the builder figures will decrease internal volume; the point is to direct as much sound as possible at the judges' in-car microphone.

The enclosure shapes are as goofy and angular as a stealth fighter's. Some work, some don't. "It's just guesswork," Irving admits. "You start with one thing and if it works, you make the airspace smaller. If that works, you make it smaller again. A lot of it is unquantifiable physics. You're trying to get the wavelength so it matures right at the microphone."

Says Valenti: "We could move one

piece and the level might go up 10 dB, but it takes a lot of time and work. I could be sitting on a number higher than anybody, if I move that back wall forward a foot."

Valenti admits he's often asked why he pursues this hugely pointless hobby. "Yeah, it's weird. But there are people who have tens of thousands of dollars invested in stamp collections, for God's sake. That to me is weird."

As Troy Irving's partner, Jason Bradley, explains, "You start out with a nice stereo in your everyday car, and it grows and grows and eventually gets out of control. The sad thing is, I don't even have a stereo in my daily driver anymore," he says, laughing. "Every dime I have goes into this equipment."

How does a sport like this do in tough economic times? Just fine. There are 465 events listed in the current season. "Our competitors can't even spell recession," says dB drag racing impre-

sario Wayne Harris. "They're young, and some of them still live at home. They put all their energy and money into their cars. They're competitive. They're at that age."

Most of the teams wear sponsor-

down a 155.8 to win his category in the Super Street class. "Yeah, I play music through the system," he tells me. "Be silly not to." What a good idea. Does he have any interest in moving up to the Extreme classes? "No, they're

"You start out with a nice stereo in your everyday car, and it grows and grows and eventually it gets out of control."

bedecked uniforms and have race-painted and decaled cars. "Pit crews" of six or eight suited-up mulleheads often tend to the cars. So it came as a shock when Jason Parsons drove onto the ramp in his clean, stock, unmarked '87 Impala and all by himself threw

out after world records. That and tax write-offs for their audio shops."

Ah, now I get it. ■

To learn more about the dB drag racing competitive season, which ends Sept. 21, go to www.dbdragracing.com.



Feel free to sound off to Stephan Wilkinson at manandmachine@time4.com

CHOOSING A DESTINATION FOR SUV SERVICE IS EASY.

MasterCare® SUV Service at Firestone keeps your SUV ready to take you wherever the action takes you. We offer SUV service and expertise that compares to any dealership, including: Oil changes • Air conditioning • Brakes • Batteries and Electrical • Radiator Service • Tune-ups • Wheel alignments • Steering and Suspension • Tires and Tire Service



MasterCare Triple Guarantee:
Fixed right • Priced right • Right on time.

See store for details. Limited warranty on-life guarantee and year model optional.

And all the convenience you need, with: 1,500 locations nationwide • Certified technicians • Evening and weekend hours • Convenient Credit Terms • Plus, your MasterCare Service visit includes a Free Maintenance Schedule based on manufacturer scheduled service intervals for your make and model SUV. Just ask.



For a Firestone location near you visit www.MasterCareUSA.com

YOUR FREE GETAWAY DESTINATION MAY TAKE SOME THOUGHT.

YOUR GIFT WITH ANY SUV SERVICE, A FREE ADVENTURE GETAWAY

2 NIGHTS • 3 DAYS ACCOMMODATIONS* • A \$175 VALUE!

Right now, with any MasterCare SUV service, get a free Adventure Getaway at your choice of over 80 resorts, from Kona, Hawaii to Scottsdale, Arizona; Calgary, Alberta to Cabo San Lucas, Mexico.

Special trial offer now through 7/31/03:

MasterCare® PLUS LEVEL OIL CHANGE \$19.99*

Compare to our standard level service; features additional engine protection for your SUV. Includes new oil filter and refill up to 5 quarts Kendall® motor oil.

*Purchase any MasterCare SUV service for your SUV between June 1 and July 31, 2003 and receive a voucher good for a 2-night stay at one of over 80 resort properties. See www.MasterCareUSA.com for details. *Subject to availability. *Not valid for vehicles with oil life monitors. *Oil change includes oil disposal fee. *Resort selection of over 80 resort properties limited to United States and Canada. Taxes & Service Centers. Shop charges of up to \$2 may be added. Not applicable in New York or California. Not to be combined with another offer and not to be used to reduce outstanding debt.

CRIME SEEN

BY JESSICA SNYDER SACHS
AT THE INTERSECTION OF
SCIENCE & CRIME

A Spielberg in Your Own Mind

If eyewitness memories are missing, the brain makes them up, and scanning technology has a hard time telling real from fake.



SITTING IN HER OFFICE AT Claremont Graduate University in California, cognitive psychologist Kathy Pezdek flips open a case file for an upcoming homicide trial—a drive-

by shooting in which the victim's girlfriend will take the stand to identify the accused. The defense has retained Pezdek as an expert on the reliability of eyewitness memory.

"For starters," says Pezdek, "I see here that the first time the girlfriend talks to the police, she tells them, 'I didn't actually see the guy's face.'"

That's a problem for the prosecution,



FREEDOM ISN'T FREE.

Today, men and women across the U.S. are stepping forward to protect freedom and their fellow Americans. Many are members of the Army National Guard. They are citizen-soldiers. Most serve one weekend a month and two weeks a year, so they can answer the Nation's call, whenever, wherever, and for

as long as they are needed. And while all Americans are able to enjoy freedom, not everyone is able to be a member of this proud and elite team. Think you can? Call 1-800-GO-GUARD (1-800-464-8273) or visit www.I-800-GO-GUARD.com to learn more about the Army National Guard.



ARMY NATIONAL GUARD

I-800-GO-GUARD EXT.136 • WWW.I-800-GO-GUARD.COM

SERIOUS PROTECTION.



ARMOR ALL DOES MORE
THAN CLEAN AND SHINE.
IT PROTECTS.

CRIME
SEEN

obviously. Within hours of the crime, however, police pull someone off the street, stick him in a squad car and show him to the witness. "It could be him," the girlfriend says.

Two days later, she views a photo lineup. "Of course," says Pezdek, "she picks out the only guy who would look familiar to her." It's the man she saw in the police cruiser. "And the police tell her, 'Yeah, you picked the right guy.'"

Pezdek has no doubt that, with coaching, the prosecution will have a confident eyewitness on the stand. "Problem is, the jury hasn't seen her progression from 'I never saw his face,' to 'it could be him' to 'yes, I'm sure.'

In other words, the prosecution will present to the jury a fine courtroom drama, sans the editing job that produced the final cut.

Our memories are, to some degree, like a final-cut videotape: Research confirms that each of us continually edits and splices recollections, replacing one "picture" with another, sometimes with a little outside assistance. "Memory is a creative event, born anew every day," says Elizabeth Loftus, a University of California, Irvine, psychologist who is a leading expert on the malleability of eyewitness testimony. "You fill in the holes every time you reconstruct an event in your own mind."

A decade of intensive research has taught Loftus and her colleagues how easy it is to plant false memories. In experiments, they've demonstrated that few people, if any, can reliably distinguish between memories of something they've been shown and something they've been asked to imagine.

The trick works on the public at large too. Forensic psychologists weren't surprised that what seemed to be a mass hallucination followed the first D.C. sniper shootings last fall. Jumpy residents jammed the FBI's hotline with recollections of white vans and box trucks brimming with guns. All it took to set the editing rooms working were news reports of such a vehicle seen speeding away from an attack.

Not that prompting is even necessary. According to memory-reconstruction expert Charles Weaver at Baylor University, we tend to alter a few details of memory with every early replay. Moreover, the retouch job of a vivid imagination can come across as far more compelling than the washed-out "first take" of our physical senses.

"Eventually, people seem to get their personal story together and stick by it," says Weaver. "But in essence, they've created a memory after the fact." Weaver's studies also show that people tend to become more confident each time they repeat their story. Hence, lawyers prep eyewitnesses: Rehearsal leads to testimony uttered with useful confidence. Throw in a few leading questions, and you have a polished, custom-edited eyewitness account.

A few weeks after Sept. 11, 2001, Pezdek and Weaver began asking hundreds of college students to recall what they saw and felt on the day of the terrorist attacks. More than 70 percent remembered seeing footage of the first plane striking the World Trade Center. Many

"My dad taught me two simple rules about car care."

Kyle Petty

recalled feeling rage toward Osama bin Laden. In fact, neither the footage of the first plane nor hints of al Qaeda's involvement became available until the day after the attacks. So much for the idea that traumatic events sear "flashbulb memories" into the circuitry. Our brains process and edit trauma just like everything else.

In some ways, though, the analogy to video replay can be dangerously inaccurate, as it suggests a library of retrievable, real footage. "Unfortunately, that's just how people tend to think of memory," says Loftus, "that we all have these videotapes of events stored somewhere in the brain if only we can find them." In fact, we assemble our memories by patching together broken pieces of stored information and then *filling in the blanks*.

One has only to view a brain-wave animation of a person viewing a familiar face to see what Loftus means. The act of remembering that face produces a flickering aurora borealis of electrical activity as the brain tries to assemble disparate bits of information pulled from every lobe of the cerebral cortex rather than a single storage place.

Most sensory information never really moves into storage at all. Like shapes drawn with a flashlight in the night air, the great mass of input from our eyes and ears fades almost immediately. Actively paying attention can buy you another 15 to 20 seconds of accurate recall by moving sensory input into short-term memory. Language appears to play a crucial role in moving memory into long-term storage, which is why the socially adept repeat the names of those they've just met. Without the "translation" of language, bits and fragments of input may make it into storage, but pulling those bits together for, say, testimony at a trial may prove problematic. When the brain can't find an intact memory, it does the next best thing—it builds one.

The terrible uncertainty of eyewitness accounts raises the question of whether science can develop a hard-wired assist for the wetware between our ears—a machine to sort false memories from real. Recent brain-scanning data suggest it may be possible, but tricky.

For years, neuroscientists trained scalp electrodes and imaging machines on the hippocampus, a small lump of gray matter deep in the brain. Known to be a memory center, the hippocampus lights up in brain scans when people look at something new or later try to remember its appearance. Early efforts centered on the hope that accurate recollections would trigger more activity in the hippocampus than would false ones, but researchers discovered that an implanted false memory was indistinguishable from a true one. Then, in 2001, Harvard neuropsychologist Daniel Schacter found that an obscure part of the brain known as the parahippocampal gyrus does, in fact, light up for true but not false memories. The work remains preliminary, but it suggests that a false-memory detector remains at least theoretically possible.

Meanwhile, juries weighing eyewitness testimony may do well to stop by the local art-house cinema for a group viewing of *Rashomon*. ■



1. Your oil gets dirty, you change it.



2. Your fuel system gets dirty, you add STP.



FUEL SYSTEM CLEANERS AND TREATMENTS



PAYING TOO MUCH NOT PERMITTED BEYOND THIS POINT.

With our Price Match Plus guarantee, if you find a lower advertised price within 30 days of purchase, we'll refund 110% of the price difference.



We're with you.

circuitcity.com

INSIDE

TOUR DE TECH Lance Armstrong's new rig

ROBOSNAKES For German sewers, a high-tech fix

HEAD TO HEAD Crane endangered animals?

BLACK HOLES They may be the source of life

TOMORROW'S NEWS Five future breakthroughs

Discoveries, Advances & Debates in Science and the World

EMERGING VIRUSES

SARS: WHERE DID IT COME FROM?

Scientists scramble to find the natural hosts before they spawn another outbreak.

In April, when Canadian scientists sequenced the genetic code of the SARS virus, they discovered a microbe unlike any other ever seen in humans or animals. On its genome "there is a long stretch of nucleotides and then one big piece that sticks out," says University of Hong Kong microbiologist Malik Peiris, who first linked SARS to a novel coronavirus. "When we then looked to see if antibodies for it exist in human blood samples, there were none."

So where did the SARS virus come from? At press

time, eight months after the first case was diagnosed in a bird and snake merchant in the Chinese city of Shunde, the source of the virus was still unknown. But researchers are narrowing the suspects to animals found in southern China, where humans and critters often live cheek by jowl.

Michael Lai, a virologist at the University of Southern California, says the virus's genome is similar to that of both a mouse and a bird virus, hinting that it may be a mix of the two. "My analysis suggests that it likely existed in a wild

animal, probably a bird. It jumped species only recently when it came into contact with a human being," he says.

In theory, SARS leapt from a wild beast to a human when it acquired the molecular "keys" to gain entry to our cells, explains Lai. To do that, it may have first mingled with a human virus brewing inside another species. A pig, for example, can serve as a genetic mixing bowl when co-infected with two viruses, allowing them to swap genes.

In a recent experiment to show how easily the coronavirus can morph and become harmful in a new species, Peter Rottier of Utrecht University in the Netherlands simulated a gene swap by taking a



"THE FACT THAT BOTH SARS AND MOST FLU VIRUSES ORIGINATED IN SOUTHERN CHINA IS NO SURPRISE," SAYS VIROLOGIST MICHAEL LAI, WHO BELIEVES THAT THE REGION'S SOCIAL CUSTOMS OF CATCHING AND EATING WILD GAME EXPOSE PEOPLE TO ANIMAL VIRUSES.



ALL ABOUT THE BIKE

Lance Armstrong's latest gear assault on the Tour de France.

coronavirus that is lethal to cats and adding a single gene fragment from a mouse virus. The recombinant virus was lethal to both animals. "Coronaviruses have a unique ability to mix with other viruses," Lai says.

Meanwhile, scientists from Lyon to Winnipeg are spraying, injecting, and orally feeding the coronavirus to monkeys, dogs, cats, mice and rabbits. Goats and sheep are next. "We want to see how they react to high doses of the virus, how susceptible they are, which replicate the virus, which excrete it, which show antibodies," says Klaus Stöhr, chief SARS scientist for the World Health Organization's Animal Influenza Network.

Once the lab tests yield more specific clues, experts like Stöhr will comb the ground in southern China to pinpoint the SARS animal hosts. Doing so will help scientists develop strategies to

intercept other emerging animal-borne viruses.

The WHO already maintains an active surveillance of animal flu viruses in the region, where both the 1957 Asian flu and the 1968 Hong Kong flu, which together killed

some 1.5 million people, originated. So did the 1997 avian flu and possibly the 1918 Spanish flu, which claimed 20 million lives. All have been linked to animal hosts. For this reason, a similar surveillance system is being established for coronaviruses. In the end, says Stöhr, "there's no point in conquering SARS as it exists now, only to have something similar or related swirling in an animal reservoir, waiting to spark the whole thing all over again." —JOANNE LEE-YOUNG

BY THE NUMBERS

WHERE SARS HIT HARDEST

NUMBER OF DEATHS BY AREA*

CHINA	267
HONG KONG	227
TAIWAN	30
SINGAPORE	28
CANADA	23
VIETNAM	5
MALAYSIA	2
PHILIPPINES	2
THAILAND	2
SOUTH AFRICA	1
UNITED STATES	0

*As of May 14, 2003
SOURCE: WHO

► **FREAKISH LUNG CAPACITY AND IRON WILL AREN'T THE ONLY FACTORS BEHIND LANCE ARMSTRONG'S PHENOMENAL SUCCESS. HE'S ALSO ONE OF THE MOST TECH-OBSSESSED RACERS ON THE CIRCUIT. SLICK GADGETRY (MOST OF WHICH YOU TOO CAN BUY) WILL AID EVERY ASPECT OF THE 31-YEAR-OLD TEXAN'S BID TO WIN A FIFTH CONSECUTIVE TOUR DE FRANCE TITLE IN JULY. AN ULTRALIGHT CARBON FIBER BIKE FRAME, WIND-TUNNEL-TESTED AERODYNAMIC HANDLEBARS AND A 57-FUNCTION BIKE-MOUNTED COMPUTER ARE JUST A FEW OF THE TECH INNOVATIONS HE'S BETTING ON. WHETHER SUCH AN ARSENAL OF ENVIEBLE CYCLING GADGETS WILL HELP ARMSTRONG WIN THE THREE-WEEK, 2,010-MILE RACE IS HARD TO SAY. BUT THIS MUCH IS CERTAIN: IF LANCE RIDES IT, THE GEAR MUST BE WORTHY.** —MARK RIEDY

1 FRAME: Armstrong will mount a prototype Trek OCLV 2-pound carbon fiber frame for the tour's 17 long-distance road stages. The rig sports an aerodynamic fin that extends toward the rear wheel, and multishape top and down tubes that keep the frame's weight low while maximizing stiffness and handling. It will retail next fall for about \$2,500.

2 DRIVETRAIN: The drivetrain turns raw leg power into road speed while handling an average prd's more than 100,000 yearly gear changes. So it had better be efficient. This spring Shimano introduced a 10-speed version of its flagship Dura-Ace components (drivetrain and brakes). Among just a handful of racers to have Shimano's 10th cog on the rear wheel, Armstrong will gain an additional two gears over his old system, helping him find just the right cadence on arduous mountain ascents. Also onboard: a lighter crankset and more ergonomic shift-and-brake levers.

3 HANDLEBARS: For the regular road stages, Armstrong won't experiment with his traditional Deda Elementi aluminum bars, seen here. He will, however, try out new ultralight carbon-and-aluminum Bontrager time-trial bars designed and tested in Texas A&M University's wind tunnel last November. The bars position his arms close together and roll his shoulders down and forward to minimize wind resistance. Put your wallet away: The handlebars are custom-designed for Armstrong's singular anatomy.

4 DUDS: To beat the scorching July sun, Armstrong will slip on Nike's new HC jersey. It's 27 percent lighter than a standard Lycra or CoolMax top and combines three densities of fabric for superior ventilation. Far the time trials, Armstrong will wear Nike's new Swift Spin skin suit. It's made of four types of patented Zoned Aerodynamics fabrics that cover different body parts, depending on their volume and exposure to wind. Nike's apparel innovation director, Rick MacDonald, says the suit could save Armstrong up to a minute in an hour-long trial. It's strictly for the pros, but the HC top will retail for about \$100.

5 WHEELS: Armstrong will spin a new wheel set made by sponsor Bontrager Wheelworks and Component. Dubbed the Triple X, it uses just 20 spokes in front and 24 in rear, making it lighter and more aerodynamic than a traditional 32-spoke wheel. Triple X wheels rely on featherlight 11-ounce carbon fiber rims and hubs, and weigh just 3.75 pounds per pair, making them some of the lightest hoops on Le Tour. Retail price: \$1,600 per pair.

6 CYCLO-COMPUTER: A handlebar-mounted computer will continually feed the racer updated numbers on his heart rate, altitude, ambient tempera-



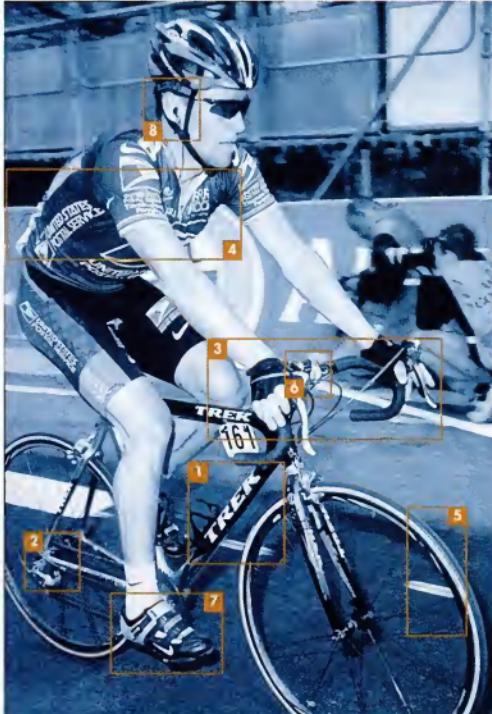
ture, speed and more. The 57-function HAC 4 Plus computer made by the German company CicloSport retails for \$420 and adds just 2 ounces to the bike's total weight.

7 SHOES: Armstrong spends perhaps 1,500 hours a year in his cycling shoes, so they've got to fit perfectly. This January he took delivery of two pairs of size-9.5 hand-made custom Nike shoes. Synthetic kangaroo-leather uppers, ultra-stiff soles made from seven layers of carbon fiber, and a Pebax resin heel/midfoot cage keep the weight to about 10 ounces per pair. The shoes will retail next year for about \$250.

8 RADIOS: To keep tabs on Tour rivals and plan tactics, Armstrong and his U.S. Postal Service team will use credit-card-size Alinco DJ-C5T dual-band two-way radios. This year the radios were specially configured (the team isn't saying how) to avoid eavesdropping.



CLOCKWISE FROM TOP: JOHN PIERCE/PHOTOSPORT; YUJI SANO/PHOTOSPORT; JOHN B. CARNETT/21; JOHN PIERCE/PHOTOSPORT [3]; COURTESY USPS PRO CYCLING; MOSQUITO [4]



THE POPSCI OPINION POLL
BASED ON 1,678 RESPONSES POSTED
TO POPSCI.COM FROM 4/24 TO 5/8

MALARIA KILLS
AN ESTIMATED
1 MILLION
PEOPLE EVERY
YEAR. SHOULD
SCIENTISTS AND
POLICY
MAKERS
ATTEMPT TO
GENETICALLY
ENGINEER THE
ERADICATION
OF ITS PRIME
CARRIER, THE
MOSQUITO?

[NO]
TOTAL EXTINCTION
IS UNETHICAL

30%

[YES]
THE BENEFITS OUT-
WEIGH THE RISKS

70%

THIS MONTH'S
OPINION POLL:
IS CLONING
THE ANSWER
TO SAVING
ENDANGERED
SPECIES, OR
WILL IT
UNDERCUT
HABITAT-CON-
SERVATION
EFFORTS?

WHAT DO YOU THINK?
[WWW.POPSCI.COM/
OPTION](http://WWW.POPSCI.COM/OPTION)

ASTRONOMY

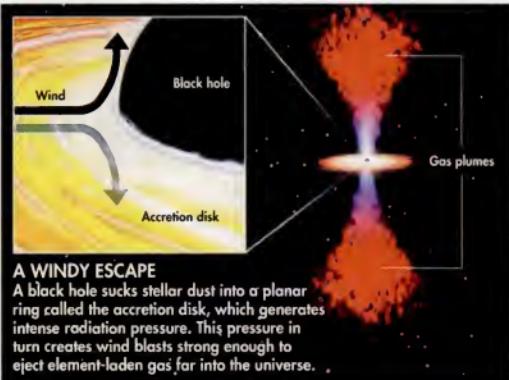
LIFE IS A BREEZE

Scientists say black holes may pepper the universe with the stuff of stars.

► "We are all made of star stuff," said Carl Sagan, describing how dead stars birthed the building blocks of life. Astronomers have theorized that titanic star explosions create carbon, oxygen and other elements, then eject them into nearby interstellar space. Now researchers say a newly observed dispersal mechanism likened to a galactic sprinkler system may be strong enough to hurl the "star stuff" far beyond local galaxies, seeding the universe with the ingredients of life.

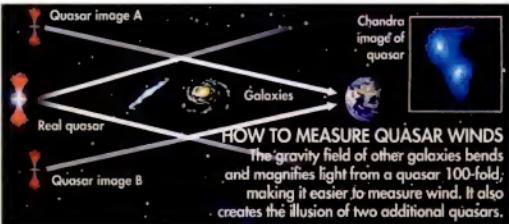
Astronomers at Penn State and MIT made the recent discovery using NASA's Chandra X-ray Observatory and the European Space Agency's XMM-Newton X-ray telescope. They measured gas winds whipping 74,500 miles per second—40 percent the speed of light—from two distant quasars, or active galaxies, that sit roughly 10 billion light-years away from Earth, and glow with the intensity of 10 trillion suns.

The researchers say the winds arise near each quasar's black



A WINDY ESCAPE

A black hole sucks stellar dust into a planar ring called the accretion disk, which generates intense radiation pressure. This pressure in turn creates wind blasts strong enough to eject element-laden gas far into the universe.



HOW TO MEASURE QUASAR WINDS
The gravity field of other galaxies bends and magnifies light from a quasar 100-fold, making it easier to measure wind. It also creates the illusion of two additional quasars.

hole center, where a voracious gravitational vacuum tears apart and devours stars. As the star debris swirls toward the hole, it emits intensely heated X- and ultraviolet radiation that in turn generates brute gusts of wind powerful enough to escape the tug of gravity (graphic, above).

Once beyond the black hole, the winds blast toward interstellar and intergalactic space, transporting star debris peppered with carbon, oxygen and iron, explains

Penn State astrophysicist George Chartas, who led the research. "The winds we measured suggest that as much as a billion suns' worth of star matter may be blown away over the course of a quasar's lifetime."

If the team's observations hold true, the winds could be kick-starting the creation of new stars while seeding large tracts of celestial real estate with the key ingredients necessary to create life-sustaining planets.—ANDREW FAZEKAS

PREDICTIONS



HEADLINES FROM THE FUTURE BY ANDREW ZOLI

2005 SOCKS THAT NEVER SMELL Researchers at the City University of New York develop nanomedicines woven into clothing that kill bacteria and fungal spores. **2010 RETIRING THE SSN** Lawmakers approve a fully digital, encrypted Citizen ID number to replace the SSN. **2015 THE CHECKUP JOHN** Engineers at Matsushita in Japan commercialize the first toilet to measure urine sugar levels and analyze body fat. **2020 DEEP THINK** A computer wins a Nobel Prize for Physics or Chemistry. One imponderable: What will it do with the money? **2040 TOO FAR OUT** NASA completes a \$40 billion space elevator that stretches 22,236 miles skyward from the equator, lifting tourists and supplies into orbit.



new driver: \$280

new hard drive: \$102

keeping business and pleasure separate (at least on your credit card): priceless



for more ways the MasterCard BusinessCard® can help keep track of
small business expenses, go to mastercardworking.com or call 1-866-MCWORKING.
there are some things money can't buy. for everything else there's MasterCard.®



ARTIFICIAL INTELLIGENCE

A ROBOT GETS DOWN AND DIRTY

Coming to German sewer pipes this summer: Robotic snake inspectors.

Meet MAKRO, the world's first untethered robotic sewage pipe inspector. Developed by researchers at the Fraunhofer Institute for Autonomous Intelligent Systems in St. Augustin, Germany, MAKRO's segmented, wormlike design gives it unprecedented mobility, allowing it to maneuver around sharp bends and climb over soggy refuse, tree roots, even stairs, says designer Hermann Streich. Existing sewerbots are leashed to power supply cables and can only move forward. The 2-meter-long, waterproof MAKRO, on the other hand, is completely wireless and two-headed so it can navigate in reverse; it's also equipped with sensors, cameras, and a 166MHz Pentium II main processor that help it prowl in the dark and videotape pipe defects. A prototype will make a test run in some of Germany's 360,000 kilometers of public sewage pipes this summer.—HAROLD FRANZEN



MOTRING

Six wheeled segments made of aluminum and plastic and connected by ball-and-socket joints form MAKRO's body. Each joint houses angle sensors and three motors that can rotate the joint 90 degrees in any direction.



SMART SENSE OF DIRECTION

MAKRO's "eyes" consist of infrared and ultrasound sensors (shown) embedded in its identical head and tail segments. The sensors, coupled with artificial neural networks and a pre-programmed onboard mapping system, help it navigate in the dark, spot obstacles and modify its course in real time.



EYEING PROBLEMS

To document pipe defects, MAKRO is equipped with an underwater video camera and a pen-size crosshair laser (red) that projects light into the tunnel. The robot's onboard processor detects distortions in the crosshair—a sign of an obstacle or pipe abnormality—and commands the camera to snap images. The laser also complements MAKRO's other directional sensors. A pair of 12-volt battery packs allow the robot to roam solo for two hours.



LANCE ARMSTRONG



"IF YOU'RE **TOUGH** ENOUGH, EVERY ROAD SEEMS FLAT."



SUBARU OUTBACK®

The Symmetrical All-Wheel Drive System inside the Subaru Outback gives it the off-road capabilities of the toughest SUV. While the horizontally opposed boxer engine and lower center of gravity give Outback the handling and stability of a car. For a combination that buries the competition.

SUBARU 
DRIVEN BY WHAT'S INSIDE™

Now available at leading auto parts stores:



"Lasts Longer on Tires"

More Shine Less Time for Tires™ (MSLT) is the fastest and easiest way to make your tires look their best. This long-lasting, spray-on coating makes dull, faded tires look brand new in seconds. MSLT is preferred by professional auto detailers, finicky car collectors, dealers, and enthusiasts!

MSLT is not a messy foam or drippy liquid. This easy-to-use aerosol needs no wiping. Apply 1 coat for a dull satin finish, 2 coats for high gloss. Takes just 15 seconds per tire, won't harm wheels or paint, and gives UV protection.

Other brands don't last because they're made with water and surfactants (soaps) that evaporate and wash off easily with water. MSLT contains no surfactants or water so it lasts longer, and won't "brown" tires. One application of MSLT lasts weeks on tires. Learn more, and find other retail stores at:

mslt4tires.com

Stoner, Inc. • 1070 Robert Fulton Hwy • Quarryville, PA 17501 • 1-888-STONER • code # MPSST

HEADLINES

H

FACE-OFF

SHOULD WE CLONE FADING SPECIES?

IN THIS CORNER: Robert Lanza, vice president of medical and scientific development, Advanced Cell Technology (ACT). **AND IN THIS CORNER:** Kent Redford, director, Wildlife Conservation Society Institute.

► This April, ACT scientists made the world's first healthy clone of an endangered species (banteng cows). Lanza argues that cloning is a powerful tool for saving endangered wildlife. Redford counters that cloning undercuts habitat-preservation efforts.—TOOOL WOOOR

POPULAR SCIENCE: To clone or not to clone?

LANZA: Cloning is an insurance policy against extinction. Literally a hundred species became extinct every day. When a poacher kills an animal or it dies from infection, its genes are lost forever. By cloning you are able to rescue those genes. For instance, there are perhaps a thousand pandas left in the world. If you freeze cells from these pandas, you salvage the genes that will give the species a fighting chance to survive.

REDFORD: Given all of the problems facing the conservation world, the focus on this one tool of limited proven ability and limited potential utility seems odd. Perhaps it is the powerful memory of the Frankenstein movies, the ongoing human love affair for things technological, the hope that somewhere, somehow, technology will be able to produce a *deus ex machina* solution to the seemingly hopeless crisis in which we find ourselves.

RL: Of course, habitat protection is—and should continue to be—the cornerstone of conservation. But it doesn't make a lot of sense to spend all that energy on habitat preservation if there are no animals left to preserve.

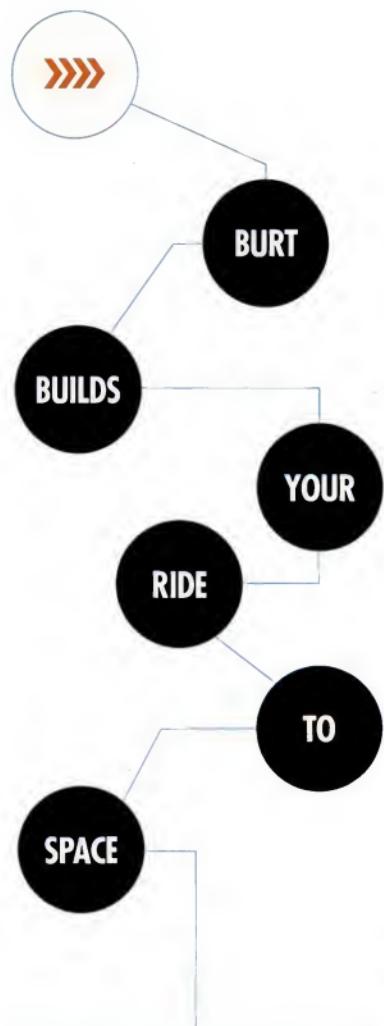


BACK FROM THE BRINK: THIS BABY BANTENG WAS CLONED FROM A 25-YEAR-OLD FROZEN-SKIN CELL.

PS: Can you envision a scenario in which cloning might prove pivotal in staving off extinction?

RL: Cloning could be pivotal when a species is reduced to a small number of individual creatures. Far instance, quite a few years ago the last remaining bucardo mountain goats [in Spain] were rounded up for a captive breeding program. However, they were wiped out by disease. The species is now extinct but could have been saved if we'd had the cloning technology we have today.

KR: There are clearly cases in which cloning may prevent extinction. However, the problem is not just the extinction of a species but also of genetic diversity, ecosystems, ecological interactions and many other components of biodiversity. Why bring a species back if it has nowhere to live? To some a zoo might represent conservation; to me it represents museum storage. Animals should be running, swimming, flying through a natural world, being eaten by some things and eating others, if that is their way.



Visionary
aircraft designer
BURT RUTAN
unveils a leading contender
in the race to get suborbital—
cheaply.

BY BILL SWEETMAN
Photograph by Misha Gravener





HAVE ROCKET, WILL TRAVEL

Sharing traits with the revolutionary X-15 rocket airplane, SpaceShipOne (above) could help launch a far-profit manned space industry. The craft will be carried aloft by the equally radical-looking White Knight before rocketing passengers an 63-mile-high suborbital thrill rides. Left: SpaceShipOne's designer, Burt Rutan.

B

BURT RUTAN WANTS TO FLY INTO space every Tuesday for five months, to test a concept and prove a point. And he wants to do it soon: He may make the first flight before the December 17 Wright brothers centenary.

Chances are, he'll succeed.

That was the buzz in Mojave, California, when

Rutan, one of the world's most innovative aircraft designers, recently unveiled what could become the first successful privately funded manned space program, a system composed of two startlingly original vehicles: the insect-like White Knight mother ship, and SpaceShipOne, a winged, rocket-propelled pod slung underneath. The pod will be carried by the airplane to 50,000 feet, then detach and rocket three occupants to suborbital altitude—more than 300,000 feet. There they will experience a brief period of weightlessness and some amazing views before heading back to Earth.

Rutan is best known as the designer of the Voyager, the aircraft that his brother, Dick, and Jeana Yeager flew nonstop around the world on a single tank of gas in 1986. If he can pull off this flight, he and his team could prove that the Holy Grail of reusable spaceship design—a low-cost spacecraft that can fly safely, frequently and on schedule—is within reach at a time when NASA's shuttle program is in a severe technical, administrative and fiscal crisis.

All the hardware built by Rutan so far is ready to go. "This isn't arm waving—this is the real thing," says Jim Benson, CEO of SpaceDev, which is developing a rocket engine for the project.

Rutan obviously has his eye on winning the X Prize, \$10 million that will go to the first team to launch a three-person spacecraft to an altitude of 62.5 miles and do it again within two weeks using the same hardware. First announced in 1996 by a St. Louis-based foundation, the X Prize is funded only until the beginning of 2005. Yet Rutan is already looking beyond that money and that deadline: He believes cheap suborbital flight will spark a renaissance in aviation and aerospace design. "If I can do this with my little company," Rutan says of his 100-person firm, Scaled Composites, which is backed in the space venture by an unnamed partner, "there will be a lot more people who say, 'I can do that too.'"

The identity of Rutan's unnamed partner has generated ample speculation. Billionaire Microsoft co-founder Paul Allen is one likely suspect. Employees at Allen's company, Vulcan Ventures, won't comment, and Kay LeFebvre, vice president of Scaled Composites, says only that "the customer has asked us to be quiet." That the "customer" might be Allen, a known aerospace enthusiast, is plausible. "Paul and I had many late-night discussions about how cool space travel would be," says Vern Raburn, who helped build Lotus and later managed

Allen's investments, and more recently founded Eclipse Aviation, a business-jet manufacturer. Raburn flew with Allen to Mojave in Allen's private Boeing 737 to discuss space exploration ideas with Rutan in 1996—the year Rutan now says his space-vehicle program was kicked off.

In building SpaceShipOne, Rutan took inspiration from the X-15, a NASA/Air Force rocket airplane that was flying routinely to the edge of space from nearby Edwards Air Force Base in 1965, the year Rutan, just graduated from California Polytechnic, arrived there as a civilian flight test engineer. SpaceShipOne "is a lot more like the X-15 than anything else," he says. Like the X-15, the new rocket airplane will ride on a jet-powered mother ship to a midair launch at about 50,000 feet. SpaceShipOne will then tilt up, zoom out of the atmosphere, reenter, and glide unpowered to a runway landing.

Launching a rocket from a jet airplane is extremely efficient. Air-breathing jets use less fuel than rockets but won't work in space, while rockets work better in a vacuum than they do in the atmosphere. Like a multistage rocket, SpaceShipOne, which is powered by a hybrid rocket engine (so called because it burns a solid fuel, a synthetic rubber called HTPB, and a liquid oxidizer—in this case, liquified nitrous oxide, commonly known as laughing gas), flies into space without the tremendous dead weight of the engines and fuel tanks needed to lift off from a launchpad. A ground-launched rocket would be three times as heavy as the 6,000-pound

SpaceShipOne.

The White Knight, with two sets of tail-control surfaces and a wide-spaced four-point landing gear, is designed so that SpaceShipOne can be trundled into place underneath. SpaceShipOne, meanwhile, with its teardrop body, multiple windows, thick, sawn-off wings and twin tails, was optimized for vertical flight. It will, when detached from White Knight, go almost straight up and down, covering only 40 miles on the ground, rather than flying as far as 300 miles downrange, as the X-15 did.

The blunt cabin is pressurized and double-skinned so that the occupants don't have to wear space suits. But don't expect an entirely comfortable ride, warns Bill Dana, a retired NASA test pilot who made the last flight in the X-15. "You're pressed into the back of your seat," he recalls. "When you launch and the engine lights, you have 2 Gs chest-to-back." As the X-15 burned fuel, it got lighter and accelerated faster. "On an altitude mission you were at 3.5 Gs at the time of burnout. It approached the pain threshold—the tendons that hold your heart to your chest wall don't usually get stressed [like that]."

SpaceShipOne's rocket motor will burn out after about 65 seconds, after which the craft continues to coast upward for about 20 seconds. At this point, there's no air and the conventional controls will be useless, so the pilot must employ gas jets to control the craft's attitude for another two minutes. During this portion of the flight, the pilot will move a lever to activate another unique feature of SpaceShipOne: The entire aft half of the wing, together with the tails, will hinge upward



TAIL COCKED: SpaceShipOne is shown here in the "feathered" position it will assume for reentry.

»»» THE NEW WAY TO SPACE

are the massive vertical fuel tanks of space vehicles past? That, of course, is the point: The small, light craft is relatively inexpensive to build, and with its piggyback configuration it requires far less fuel to reach 62.5 miles. This launch strategy, along with a massive rear wing that flips up during reentry, makes SpaceShipOne the most innovative craft gunning for the X Prize.

This is a spaceship?
It looks almost
spindly—and where



STATS

CAPACITY

2 passengers + pilot

TOP SPEED

Mach 3.5 (launch),

Mach 3.3 (reentry)

LANDING SPEED

80 mph

MAX ALTITUDE

62.5 miles

PEAK G-FORCES

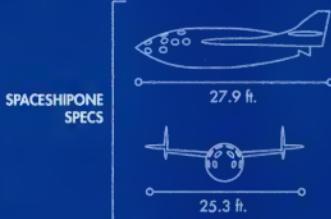
3.4 Gs (launch),

5.5 Gs (reentry)

COST

\$20-\$30 million (est.)

1
White Knight, with
SpaceShipOne
attached underneath,
takes off like a
regular airplane.



3

After a 65-second burn
expends its fuel, Space-
ShipOne continues on a
4-minute weightless parabolic
arc above the atmosphere.

4

The "feathered" wings
effectively make Space-
ShipOne a giant shuttlecock;
the craft drops like a stone,
its body leading the way.



2

After it is dropped
by the White
Knight at 50,000
feet, Space-
ShipOne points
upward and fires
its hybrid rocket.



5

At 80,000 feet, the wings lower and
SpaceShipOne turns into a glider. It
lands horizontally at the same airstrip
it departed from.



THE ROCKET

Passengers aboard SpaceShipOne (right) will experience 3.5-G acceleration on the ride up to 62.5 miles—attributable to the vehicle's light weight (approximately 6,000 pounds) and fiercely powerful hybrid rocket engine. That will be an ordeal for even the heartiest adventurer: Late test pilot Milt Thompson said of the X-15, which offered a comparable ride, that it was the only airplane he ever flew in which he was "glad when the engine quit." The three-seat SpaceShipOne will be trundled up to space via the White Knight mother ship (below right). The passenger craft attaches to the White Knight's belly for the first 50,000 feet of the journey.



THE LAUNCHER

The White Knight (left), powered by two used jet engines culled from an Air Force trainer ("the cheapest engines I could find," says the designer), shares many parts with SpaceShipOne and can be used as a simulator for the smaller vehicle. A new avionics system (above) has multiple display modes for diagnostic and navigational data.

CLOCKWISE FROM TOP: COURTESY CALID COMPOSITES; MISHA GAVRIN; COURTESY SCALD; COMPOSITE: MISHA GAVRIN

at a sharp angle. It's a completely original shape rooted in Rutan's concern for both safety and low cost. Airplane-like vehicles such as the X-15 and the shuttle have to enter the atmosphere at precisely the right angle—"if you sideslip, you die," says Rutan—and do so with the help of complex automatic control systems. In the flight simulator, X-15 pilots frequently experienced loss of control in the vacuum of space.

Rutan's goal, by contrast, is a relatively care-free reentry. SpaceShipOne falls rather than flies into the atmosphere. The flip-up tail, or "feather," is intended to lock it into a safe, stable attitude without the aid of a costly autopilot. The feather concept evolved from a simpler "shuttlecock" configuration; the design was developed by computers that model airflow around the vehicle. Natural stability was critical to make the craft practical and affordable. "Remember," Rutan explains, "affordable cost is the reason we are doing the program. Unlike the X-15, our feathered entry allows the pilot to enter hands-off. We plan to only grossly line it up for entry, then sit back and let it track by itself. We expect to be able to survive an entry from any attitude, even sideways or backward."

SpaceShipOne's flat reentry creates enormous drag, and the ship starts to decelerate as soon as it hits the atmosphere.

This keeps heat loads relatively low, around 1,100°F, which enabled Rutan to build SpaceShipOne from a lightweight carbon-fiber composite and coat it with a "troweled-on" heat-resistant layer. It's a new approach, and the few people who have flown in that envelope advise caution. Rutan, says an X-15 veteran, "is trying to stabilize the vehicle with its configuration alone. He may be successful, but he's going to have to explore his envelope in very small increments. If control looks marginal, he may have to go to an autopilot."

With that in mind, Rutan has set up a step-by-step test program, using a sophisticated simulator, to make flight-testing as safe as possible. Ingeniously, the cockpits of White Knight and SpaceShipOne are almost identical, allowing White Knight to test cockpit systems and, with carefully applied airbrakes, mimic SpaceShipOne's flight characteristics to serve as its boost, approach and landing practice vehicle. "He's approaching it as a research program," says one flight-test engineer. "If he runs into a problem, he can step back and do it again." As for Rutan's chances, he adds: "Any guy who gets up from his dining-room table and tells his wife that he's going to build an airplane to fly around the world

RUTAN'S RIVALS: "GOOD LUCK"

Even as they embraced him as amiably as suburbanites welcoming a newcomer to the neighborhood, leading X Prize contenders had a message for Burt Rutan: Bring it on.

"Many people seem to be overreacting," says John Carmack, a computer-game legend (*Doom*, *Quake*) and founder of Armadillo Aerospace in Dallas. "Burt is somewhat further along than we had hoped. But we still feel we have a solid shot of getting there first."

Adds Randa Milliron, CEO of Interorbital Systems in Mojave, California: "We're rocket experts and, frankly, Burt Rutan is an airplane expert. So let's see who wins."

Armadillo, Interorbital and most other X Prize competitors intend to mimic NASA's successful Mercury, Gemini and Apollo missions, shooting a rocket from a ground-based launchpad and landing vertically with a parachute. Rutan's craft, by contrast, takes off as an airplane, then at 50,000 feet launches a rocket that later lands like a glider.

Although Rutan's rivals admire the elegance and audacity of his design, many contend it doesn't make sense. "Our view is that a rocket shouldn't have wings," says Bill Sprague, team leader of American Astronautics in Oceanside, California.

Also, because Rutan's rocket rides piggyback on an airplane, critics say it's too small to launch cargo—or tourists—into space and so will never be commercially viable. "He's going after the X Prize, and he'll likely win the thing," says Jim Akkerman, president of Advent Launch Services in Houston. "But as far as low-cost access to space, he's not going to get it done."

The X Prize is the carrot luring teams into space, but for most teams it's not the ultimate goal. "The big challenge is to have a business when you're done," says Pat Bahn, founder of TGV Rockets in Bethesda, Maryland. "Lindbergh won fame and fortune, but [DC-3 creator Donald] Douglas made a lot more money." —PRESTON LERNER

WHO WILL SELL TICKETS?

Rutan expects someone else to commercialize his design.



and get his brother to fly it, and then goes out and does it—I've just got to listen to him."

The potential of Rutan's design isn't limited to a human payload—it could also loft small, cheap "microsatellites" into orbit for university and military customers. Observing with interest at the crowded unveiling was Gen. Simon Worden, the Air Force's director of space development and transformation. "We're excited about microsatellites," he said, "and we're considering putting serious money into them."

Rutan's historical model is Wilbur Wright's tour of France in 1908, which sparked tremendous growth in the industry. Rutan wants SpaceShipOne to kick-start a similar burst of innovation. Hence his ambitious post-X-Prize testing and demonstration plan: Fly every Tuesday for five months, 20 flights in a row on schedule, to determine the system's cost and reliability. Though he envisions everything from 10-passenger suborbital tour buses to a giant White Knight that uses eight 747 engines to launch a 300-ton spacecraft, Rutan says those are for others to build: "The Wrights didn't build the world's first airliner—they didn't need to," he says. "I hope people don't expect me to certificate a spaceship and offer rides. I want to be doing something more exciting by then."

 Is ex-Microsoft billionaire Paul Allen backing Rutan? More on the Silicon Valley connection at www.popsci.com/exclusive

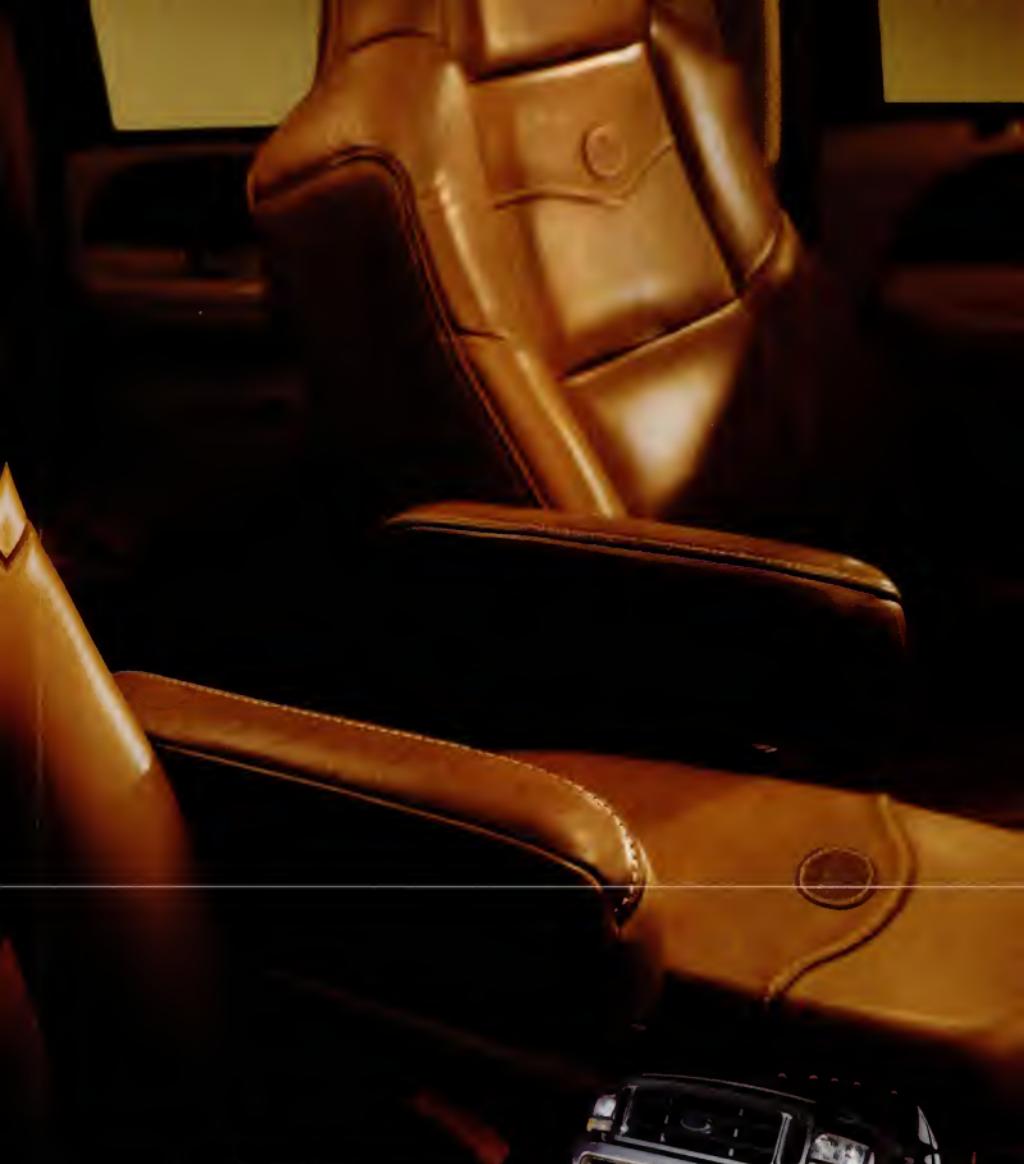
Bill Sweetman is a contributing editor to POPULAR SCIENCE.



EVERY KING NEEDS A THRONE.
FORD F-350 KING RANCH

THEY'RE SPACIOUS, COMFORTABLE AND TRIMMED IN YARDS OF RICH
CASTAÑO LEATHER. JUST CALLING THEM SEATS SEEMS INADEQUATE. SETTLE INTO A
KING RANCH SUPER DUTY AND YOU'LL FEEL LIKE Royalty.





IF YOU HAVEN'T LOOKED AT FORD LATELY...
LOOK AGAIN.



©2001 Ford Motor Company



BirdMan
Performance
Designs Inc.



IN THE SPIRIT
OF THE WRIGHT
BROTHERS
1903-2003

THE FLIGHT OF THE **BIRD MEN**

FOR JARI KUOSMA
AND ROBERT
PECNIK, SKYDIVING
WASN'T ENOUGH—THEY
WANTED TO STRAP
ON WINGS AND FLY.
SO WHAT
IF 96 PERCENT
OF THEIR
PREDECESSORS
HAD DIED IN THE
ATTEMPT?

BY WILLIAM SPEED WEED
Photographs by
John B. Carnett

IT'S A BIRD, IT'S A . . .
Jari Kuosma (center)
and two of his BirdMan con-
verts, Kevin Schafer and
Kimberly Griffin,
leap from the back of a
SkyVan 8,000 feet
over DeLand, Florida.

W

aiting on the ground for
the Twin Otter
that'll take them up, Blossom
DeRego and Jari Kuosma look
like a pair of avant-garde perfor-
mance artists posing as
flamingos, with bizarre flaps
of scarlet flowing from their

armpits and between their legs. The other skydivers, milling about in skintight ninja suits, look like superheroes. Once aloft at 13,500 feet, though, they all pour from the plane's side door, and suddenly there's no doubt who the superheroes are. DeRego and Kuosma's scarlet flaps transform into wings, and the dynamic duo swove and swoop through the sky like they're heading for the Hall of Justice.

Poor ninjas. They just drop like cannonballs.

DeRego, a personal trainer from Hawaii, recently moved to DeLand, Florida, to live in the skydiving capital of the world. With 593 jumps, she's a veteran cannonballer. But this, her first flight in a BirdMan suit, is something entirely new. The moment she's out the door, she feels as if she's flying two miles above Earth. She is flying—her body alone, unaided by plane or glider. She zings from cloud top to cloud top, screaming with glee. The suit's three wings (the flaps under each arm and between the legs) increase her body's surface area by 100 percent, cut her fall's terminal velocity by two-thirds, and propel her forward to whoosh about the sky. Kuosma, for his part, holds down the other end of the experience spectrum. He and his Croatian partner, Robert Pecnik, invented these wing suits. Kuosma's terminal velocity in the suit is a mere 35 mph—as opposed to 120 mph for a ninja-suit jumper—and with his 80 mph horizontal top speed, he can almost outpace the Twin Otter.

Kuosma and DeRego cannot gain or maintain altitude, so, technically, they aren't flying. But because even beginners can swoop two miles horizontally for every mile they drop, it sure feels like flight. After the jump, DeRego's eyes look as if they're on fire. "Wow!" she says, and then, clearly at a loss, she just repeats herself—"Wow...Wow!"—over and over. Finally, she breaks into a huge smile and speaks words that humans have dreamed of speaking at least since Daedalus built wings of feather and wax: "I was flying!" she says.

IN AUGUST 1998, just days after meeting for the first time, Jari Kuosma and Robert Pecnik drove from Slovenia to Arco, Italy, to leap off a 3,000-foot cliff. For Kuosma, this was not an entirely novel activity. He'd begun throwing himself from tall earthbound structures—BASE jumping (the acronym stands for Building, Antenna, Span, Earth)—the previous year, and had maybe a dozen jumps to his credit. In Pecnik, he had instantly sensed a kindred spirit. As a boy Pecnik had strapped homemade parachutes to hamsters and tossed them (without harm) from his sixth-story bedroom window; by the time he joined the Croatian national team he was making his own jumpsuits. Somehow, though, he had yet to do any BASE jumping, a deficiency Kuosma decided to address immediately.

Normal jumpers can free-fall for 11 seconds off the Arco cliff before they need to pull their chutes. But as they stood looking out over the Dolomites, Kuosma and Pecnik had a more ambitious model in mind. They were thinking of Patrick de Gayardon, who, wearing a winged jumpsuit of his own design, had in 1997 flown for a record 27 seconds off Arco. "A BASE

IN THE SPIRIT OF THE WRIGHT BROTHERS 1903–2003

jump is an incredible thing," Kuosma says. "But to fly off a cliff like this, now that's something!"

This dream—to fly, utterly on one's own power—is of course an ancient one, a human urge that was barely scratched by the advent of the parachute in the 1780s, the hang glider in the 1880s, the airplane in 1903. These are all still mediated experiences: It's the parachute or plane that's flying; the human's just along for the ride. Then, in 1914, Georgia "Tiny" Broadwick, who a year earlier became the first woman to parachute from an airplane, made the first-ever free-fall jump, plummeting for several seconds before pulling her chute. At last the human body was tumbling free high above Earth.

Still, you could hardly call it flying. Next step: wings. The first wings to arrive on the skydiving scene were actually designed not so much to fly as to make it safer to fall. Before Broadwick's jump, people assumed free-fall would kill you—how could one breathe while moving at 120 miles per hour? The idea that you could control your body under such extraordinary conditions seemed so absurd that no one even tried. People just tumbled out of planes, spinning chaotically and counting seconds until they opened their parachutes. If they pulled while in a warped, upside-down position that snagged the chute, they would "Roman candle" into the earth. The main goal of early birdman wings was to flatten out the tumble.

In the 1940s, Frenchman Leo Valentin solved the free-fall problem without wings. In a few short years, he invented the techniques of advanced free-fall that skydivers still use today: the stable belly-down frog position, the shooting forward arrow position, turns, barrel rolls, and, most important, the life-saving moves used to recover from spins.

Valentin's discoveries, though, did nothing to squelch the urge to fly. In fact, Valentin himself was a master birdman, who worked on dozens of wings throughout his adult life. He even wrote a book (called, naturally enough, *Bird Man*) about his efforts. Kuosma and Pecnik later took the "BirdMan" name for their suits and company to honor him. Valentin's greatest design was a pair of rigid wings so large that he needed a cargo plane to carry him to altitude. In 1956, the huge wings pulled him back into the plane's ramp as he exited during a jump over England. He knocked his head and fell into a tight spin, the massive wings overpowering his well-practiced attempts to recover stability. When he pulled, the wings' rigid structure entangled both his main and reserve parachutes. He tumbled to his death in a snarl of wings and cords and parachutes.

Valentin's fate was hardly an anomaly. From 1930 to the early 1960s, out of 75 actively experimenting birdmen, 72 were killed in the pursuit. The problem was, the technology of the time wasn't a whole lot better than Daedalus's wax and feathers. Before the invention of strong synthetic materials, fabric wings had to be reinforced by wood or metal stays, which tended to cause one of two exigencies: Either the wings would fly too well, overpowering the birdman and dumping him into a terminal spin, or his parachute cords would get tangled in the stays and not deploy properly.

It wasn't until the mid-1990s that a truly modern wing suit emerged, and it was Patrick de Gayardon who wore it. De Gayardon's wings, made of a double layer of parachute material, required no wood or metal stays. Instead, air inflated the wings and held them rigid as he flew. For years, skydivers stood in awe. "He was a daredevil," says Norman Kent, a professional skydiving photographer and an old friend of de Gayardon. Kent

recalls the gasps of onlookers when de Gayardon flew into the Grand Canyon or past the glaciers in Chamonix, France. "It was just like watching this wacko do something no one else could do," Kent recalls. To the skydiving world, de Gayardon became *the birdman*, the only mortal the gods permitted to fly.

Then, in April 1998, while testing an upgraded suit on a jump over Hawaii, de Gayardon's parachute cords got snarled, sending him plummeting at 120 mph to his death.

Standing atop the Arco cliff just four months later, Kuosma and Pecnik knew about all this—de Gayardon's recent death, the sport's 96 percent fatality rate. Nevertheless, they resolved in that moment not only to design their own wing

suits but to do something even crazier: to build a business around selling them to other skydivers.

Then they leapt off the cliff.

AS DEREKO RUSHES OFF to tell her friends about her flight, Kuosma strips off his flamingo suit, repacks his parachute for another day, and heads to the drop zone bar for a pint of Australian lager. He's wearing neon orange pants and a blue T-shirt

BUILDING A NONLETHAL WINGSUIT

Early-generation wingsuits were death machines, killing 72 out of 75 pioneers. But the BirdMan is safe enough to be sanctioned for sale by the United States Parachute Association—largely thanks to these innovative boil-out and control features.

Arms Release

Once he's opened his main parachute, a birdman must raise his arms above his head to control it. He can't use those zippers to收起 the wings until they're range of motion.

Halfway Harness

The parachute harness is integrated into the suit. Shoulder straps are outside, while the leg straps wrap around the upper thighs under the suit where they won't catch fire from the wings.

Emergency Detach

These two cables attach to a cable that runs up the back of the diver's body. The cable comes free with a yank, quickly releasing the wings in case of emergency.

Wing Support

Mesh-covered air-inlets below the armpits and crotch inflate the three wings. The inflated wings create a three-dimensional shape much like an airplane's, increasing lift.

Leg Release

Zippers also run from the foot to the thigh. A diver opens these once he has opened the parachute so he can run during landing.



with a Superman insignia on it, except the S has been replaced by an icon of a BirdMan skyflier.

Kuosma sports rakishly tousled hair and a mischievous grin; he looks like Loki, the Norse god of trickery, posing as Clark Kent.

Bird in hand, Kuosma sits at an outdoor table among a small group of skydiving acolytes and recounts the tale of how he and Pecnik managed to design wings that would not only work but be safe enough for the masses.

They started by trying to get technical specs from de Gayardon's estate but were rebuffed. "We had to reinvent it," Kuosma says.

The basics were easy: Put a double layer of parachute material between each arm and the torso, and between the legs. Give each wing a vent—in the armpits and in the groin—so that it can fill with air. Design the wings so that when they become rigid with air, they assume the classic wing profile, a shape that creates lift by redirecting the flow of air downward as it passes over the wing.

A critical determination was the angle the wing made between the torso and the arm. The larger that angle—the higher the arms can extend—the more the birdman's surface area increases and the greater the lift. At the same time, though, the larger the wing, the more strength needed to control it. At a certain point, it will get too large and overpower him in flight. Over the course of several generations of suits, Kuosma and Pecnik ultimately settled on an angle of 78 degrees for the arm wings (the arms are slightly lower than straight out to the side), and 35 degrees for the legs.

With no hard stays in the suit, Kuosma says, "everything you need to do to save your life, you can do with the wings on." A jumper can reach his main chute at the small of his back as well as the reserve chute handle on his chest. But if history taught one lesson, it was the importance of shedding the wings immediately in an emergency. So they designed two wing-cutaway systems. The first is a zipper that runs the length of each arm and frees it from the wing. During normal operations, skyfliers undo these zippers after

they've pulled the parachute so they can reach overhead and steer with their toggles.

As a backup, Pecnik designed a novel secondary cutaway that works faster than a zipper. Interdigitated loops of strong nylon, alternately connected to the suit body and the wing, attach the wings to the torso. Running through those loops is a yellow cord, which ends in a small pillow on the side of the thigh. By yanking that pillow, the skyflier pulls out the cord and detaches the wing from the suit's body. "This system was the revolution that allowed us to market the wing suit," Kuosma says. "Because no matter what happens, you can cut away the wings and become just a regular jumper."

Of course, that's an assurance born of 1,300 wingsuit flights. On his very first flight in January 1999, Kuosma wasn't so confident. After five months of planning, drawing and sewing, Pecnik brought prototypes to DeLand, one for himself, one for Kuosma and one for Kuosma's then-girlfriend, a member of the Norwegian national skydiving team. Their mission: to test-pilot their own bodies from 13,500 feet.

What are your thoughts as the Twin Otter gains altitude and you're about to leap out wearing the sort of suit that has killed almost all of your predecessors? You wish you could test it somewhere safe. Vertical wind tunnels do exist, but they're only a few yards across; a birdman will bang into the walls. You have no choice but to test it from a plane—the higher the better because you'll have more time to react if something goes wrong. "I thought of the history," Kuosma says. "Of how Patrick—the god of this sport with 14,000 jumps—had died doing it. You're stepping into the complete unknown. You have to commit everything you ever knew or cared for. I gave myself a 50-50 chance."

All three jumped at the same time. Their fears vanished instantly. "Right from the door we were flying," Kuosma says. "It was an incredible experience. You pick a spot, a canyon between two clouds, and you fly there. You can play with your own shadow against the cloud. When we landed, it was like a big lightning: This is what I want to do, I thought, and this is what I want every skydiver to experience."

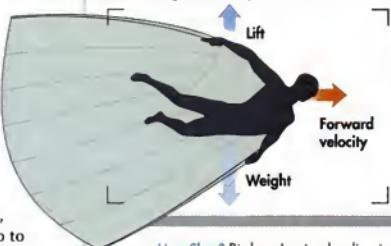
A WING AND A PRAYER

Kuosma and others want to land safely, sans parachute. But without bigger wings, the laws of physics are a bit of an impediment.

The Basics. Both velocity and wing loading—the ratio of weight to wing area—determine lift. The more weight and the smaller the wings, the faster a flying object must move to stay aloft.



BirdMan's Dilemma. With small "wings," BirdMan must move fast to maintain lift. Large wings—12 feet long—would allow for reasonably slow landings. Yet the added force in flight would rip his arms off.

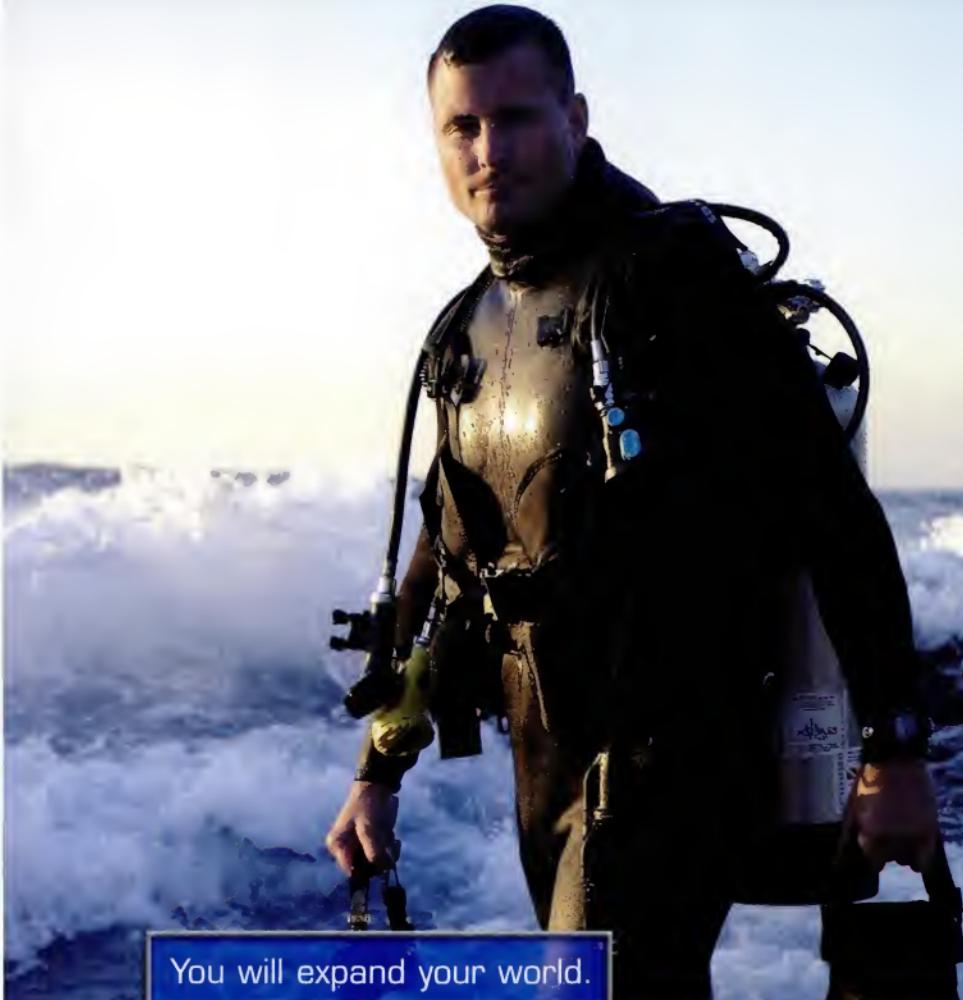


How Slow? Birdman's wing loading is 90 pounds per square foot (psf), his minimum speed 90 mph. Compare to other high flyers:

Joint Strike Fighter
130 psf/160 mph

Cessna 172
14 psf/60 mph

Flying Squirrel
1 psf/3 mph



You will expand your world.



Every day exciting choices, possibilities and experiences present themselves. Make learning about the Naval Reserve the next important thing you explore. Providing great support to our nation and your life, the Naval Reserve offers you many rewarding areas of opportunity. To find out about all the benefits and options available for part-time Reservists, visit our website or give us a call.

www.navalreserve.com
1-800-USA-USNR

**NAVAL
RESERVE**
STAY STRONG

BY LATE SPRING of that year, Pecnik had made 85 suits in a factory in Croatia. Kuosma threw them into the trunk of his car and showed them off all over Europe. In August, a year to the day after they had first jumped together at Arco, the two rendezvoused at the cliff in full BirdMan regalia. Both flew for 27 seconds, matching de Gayardon.

In the spring of 2000, they broke a distance record with a demonstration flight in Holland. Dropped at 16,000 feet over the offshore island of Texel, Pecnik, Kuosma and four others flew their BirdMan suits three miles over the Strait of Marsdiep, then opened their parachutes and landed on the mainland. The stunt got noticed, and BirdMan suits started selling.

Three years later, they've sold more than a thousand. Design modifications have extended the length of the wings without increasing the angles, and have tweaked the flier's profile to better approximate a classic wing shape. Recently, in a fourth-generation suit, Pecnik flew for more than a minute off Arco before pulling his chute.

Tens of thousands of skyflights are made each year. So far, only one skydiver has died wearing a Bird-Man suit—but it was one he'd borrowed, violating Kuosma's training—is essential ethic. He won't sell a suit to anyone with fewer than 200 jumps—experienced skydivers, he says, handle emergencies more calmly—and anyone with fewer than 500 jumps must take a safety course. Curiously, the course doesn't emphasize how to fly. "I don't have any technique to teach you," Kuosma told DeRego. "You know how to do it already. Just think about where to go and you'll turn."

What Kuosma does teach DeRego is to keep her arms symmetrical; an imbalance could spill her into a spin. If you feel the wings overpowering you, he says, pull your arms and legs in, reducing surface area. If it gets really bad, just cut the wings away. Above all, if it ever feels scary, pull your parachute. Kuosma learned that lesson in February 2000 while testing Pecnik's latest design. "Robert thinks I am his hamster now," Kuosma says with a laugh. "These wings were much longer and larger than we'd ever tried." The suit performed so well that it overpowered his shoulder muscles. "Super fast, I knew this flight was no longer under my control," he says. "I instantly remembered why all those early birdmen died, so I pulled my parachute, before the forces grew so big that I could not open it."

All in all, though, dangerous spins are a rarity among



"THE ULTIMATE GOAL, HE SAYS, IS TO FLY TO THE GROUND AND LAND WITHOUT A PARACHUTE."

skydivers. A bigger concern, Kuosma says, is the tendency to focus too much on the fun and not enough on the ground. "Sometimes people are flying too low before they open their parachute," he says. "It's such an amazing feeling that you think you can take it all the way down."

AND WHY NOT? As twilight and the last of the day's parachutes descend on DeLand, Kuosma, now on his second pint, grins around the table at the other skydivers. "Maybe we have to add a little engine to the back for thrust," he says. "And we definitely need to improve the overall profile of the flier. But the ultimate goal is to fly to the ground and land without the parachute."

Kuosma's scheme inspires enthusiastic nods among the other skydivers, but not everyone is so supportive. "They're deluding themselves," says MIT Professor of Aeronautics R. John Hansman. The problem, he says, is a number called wing loading, the ratio of an airplane's weight to its wing surface area. A light sailplane has a wing loading of about six pounds per square foot of wing, which allows it to land at very slow speeds. A fighter jet, with a wing loading of 100 pounds per square foot, requires landing speeds of 120 to 150 miles per hour. Since our own strength limits how big

our wings can be, human beings, with our dense bones and muscles, will always have a wing loading in the fighter plane range, and we'll have to land at similar speeds. "The problem isn't the landing," quips Hansman. "It's the landing gear. Our legs won't run fast enough."

Kuosma, though, does not blemish at the arguments of skeptics. "All our inventing so far has been a back-of-the-envelope thing, just two guys with a tiny budget," he says, conveying the implicit "and look at what we've done!" through his grin. He and Pecnik dream of corporate sponsorship—"a few million dollars and the right precision measuring technologies to see where we can improve the suit."

As for the landing gear problem, well, Kuosma has thought about that too. "We'll have to land in foam, maybe, to absorb that speed," he says. "Or on a ski slope like a ski jumper." Blind hubris? Maybe. But it would be his own hamster body that Kuosma would be putting at risk. And can you blame him for trying to be the first to take the ancient dream of flight all the way to a safe landing? ■

William Speed Weed jumped from an airplane for the first time while reporting this story. He writes regularly for National Geographic Adventure and The New York Times Magazine.



The birdmen who didn't survive: www.popsci.com/exclusive

really cool.



completely cordless.

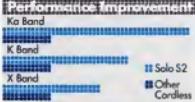
Introducing the revolutionary
SOLO S2 battery powered radar/laser detector.



Never before has any detector been able to provide this level of world class performance with the convenience and portability of a cordless design. But, then, there's never been any detector like the all-new SOLO S2 battery powered radar/laser detector.

400% More Range

The completely re-designed SOLO S2 is a technological breakthrough. It provides long range detection that was never before achievable in a battery powered detector. In fact, SOLO S2 has an astonishing 400% more range on Ka band radar than any previous cordless model.



battery powered detector. In fact, SOLO S2 has an astonishing 400% more range on Ka band radar than any previous cordless model.

Incredible Convenience. Serious Performance.

The all new SOLO S2 offers a complete array of amenities, each designed to enhance your driving experience:

- Convenient cordless design means complete portability. It's easily moved from vehicle to vehicle. And, it's perfect for trips.

- Ultra performance against every form of radar and laser
- A remarkable high-resolution display that looks great, day or night
- Patented AutoSensitivity™ technology that virtually eliminates false alarms
- High performance Laser circuitry that provides maximum Laser warning, and superior off-axis protection
- A sophisticated on-board processor that can be re-programmed to meet future radar and laser threats. Your unit is never obsolete.
- Longer battery life...powered by two AA batteries

Performance and Convenience – Guaranteed.

The revolutionary SOLO S2 is the best battery powered detector ever. It comes with its own carrying case so you can take it with you wherever you go. Order yours today. We're so confident that you'll love it, we'll let you test-drive it for 30 days – completely risk free!

The re-invented SOLO S2. Cordless convenience. Escort performance.

Cordless Solo S2 \$329.95

Plus S&H. OH residents add 5.5% sales tax
Escort Inc. 5440 West Chester Road
West Chester, Ohio 45069
513-870-8500 • Fax 513-870-8509
► Department 201673

Call Toll Free 1-888-8 ESCORT
1-888-837-2678

ESCORT

DETECT THE DIFFERENCE

www.escortradar.com

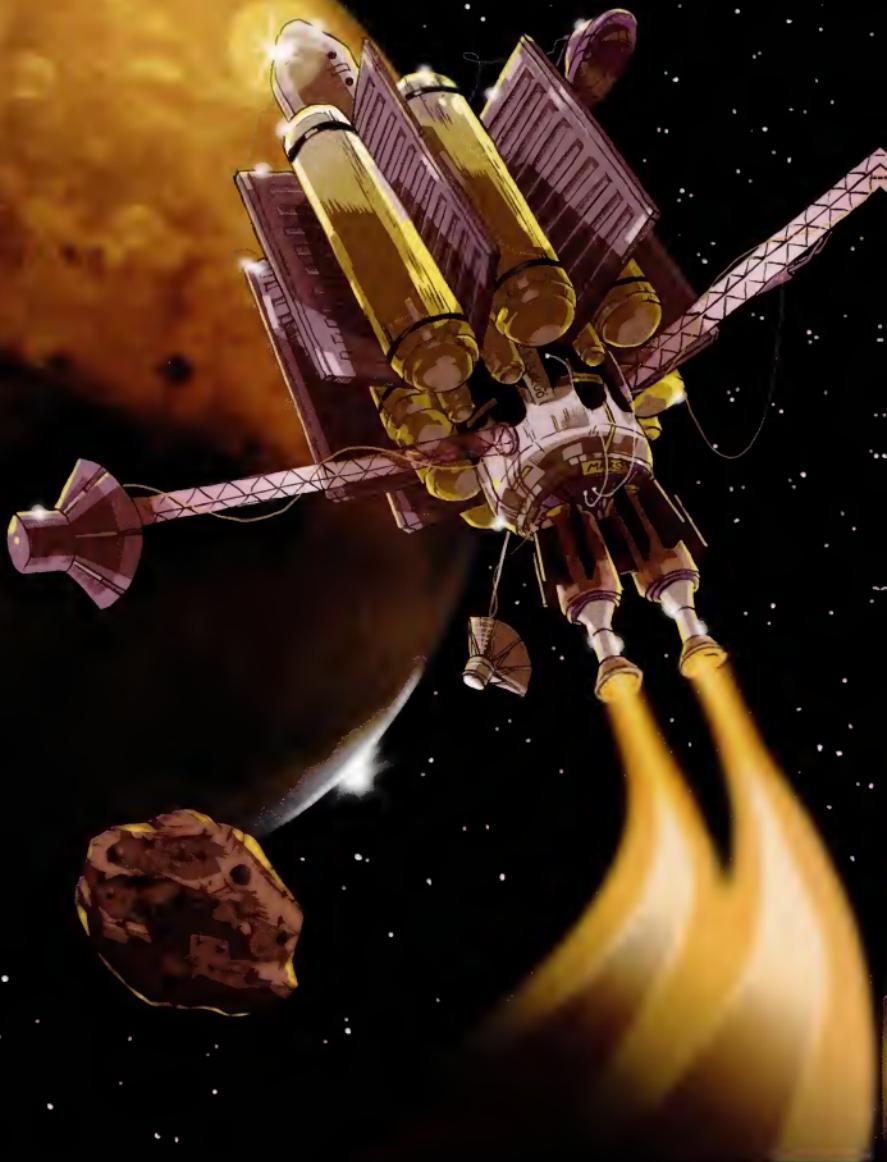
©2002 Escort Inc.

RED PLANET BLUES

2020? 2050? NEVER?
PREDICTING THE DATE
HUMANS WILL SET FOOT
ON MARS IS, IF
ANYTHING, BECOMING
MORE DIFFICULT.
INTENSE RADIATION,
ZERO-G BONE LOSS,
LETHAL MARS DUST, AND
MURDEROUS CABIN
FEVER ARE JUST A FEW
OF THE MISSION'S
UNSOLVED PROBLEMS.
*HERE'S A CHALLENGE TO
GET NASA HUMMING
AGAIN.*

[The Bekuō cruises past Phobos, a small, rocky Martian moon.]

THE FAST PLASMA-PROPELLED BEKUO NEARS MARS AFTER A THREE-MONTH SPRINT



IN THE LATE 1990s, PLANETARY

geologist John Marshall got NASA's approval to analyze the plastics and fabrics that engineers were developing for the gloves, boots and space suits that astronauts would use on a future Mars mission. Marshall put the materials in a wind tunnel near his laboratory at NASA's Ames Research Center and blasted them with a red clay composite similar to Martian dust. The dust took to the materials so strongly it was almost impossible to wipe off. "It looked like someone had spray-painted it on there," recalls Marshall, a researcher at the SETI Institute.

It was a potentially catastrophic choice for gear to be worn on dust-swept Mars: Clinging to the astronauts' suits, the dust

would have been carried into their living quarters, where it would have abraded pressure seals, ground up computer disk drives, shorted out electronics, and possibly even made crew members sick. Samples of those ill-chosen materials remain in Marshall's laboratory some four years later, as dust-covered as ever. They serve as a reminder of the unexpected challenges that bedevil Mars researchers. "I'm always humbled by what we don't know about Mars," says James Garvin, NASA's chief scientist for Mars exploration.

THIRTY YEARS AGO, AFTER THE APOLLO PROGRAM MADE getting to the Moon look simple, it was easy to imagine the entire solar system lay open for human voyages. Top aerospace engineers hoped for a manned flight to the Red Planet by 1981. Now it seems likely that an early mission would have been a catastrophe. For example, to protect against harmful radiation, engineers in the 1970s would have built the spaceship's skin out of aluminum. But recent studies have shown that high-energy cosmic rays spall powerful secondary outbursts off aluminum atoms. An aluminum "shield" would have endangered crew members instead of protecting them. Some of the other challenges to a Mars mission—which would last up to three years, as opposed to the week or so it took to get to and explore the Moon—include safeguarding the physical and mental health of astronauts; developing appropriate equipment, as well as the backups and repair gear needed when it breaks; and ensuring adequate food, water and other supplies, since restocking from Earth will be impossible.

Time has done nothing to blunt the scientific drive to explore Mars. Indeed, recent discoveries have only heightened it. Data collected by spectrometers aboard Mars orbiters suggest there may be water under the surface. Water implies life—or at least traces of past life. Geologists, meanwhile, want to know how Mars became so dry and dusty, and whether the planet holds clues about Earth's own fate. A Mars trip would test the human capacity to survive in non-terrestrial conditions.

Given Columbia-inspired questions about the costs of human spaceflight, NASA is hardly banging the drum for a manned Mars mission. Current plans call only for orbiters, robotic rovers and, possibly, sample collection equipment—not people—to be sent to the planet until at least 2020. But the agency's 2004 budget request earmarks \$4 billion for space science, a \$532 million increase over 2003. Some of that money will go to support the many experimental programs that are doing essential prep work for a Mars voyage.

"We want to research what we call the 'known unknowns,'" says John Charles, senior staff scientist at NASA's Space and Life Sciences Directorate. "This will reduce total risk in the face of the unknown unknowns, the true surprises out there." The following is a look at the primary areas of investigation.

GETTING THERE // When *Apollo 11* went to the Moon in 1969, it rode aboard the massive Saturn V rocket—363 feet high and weighing more [\(CONTINUED ON PAGE 69\)](#)

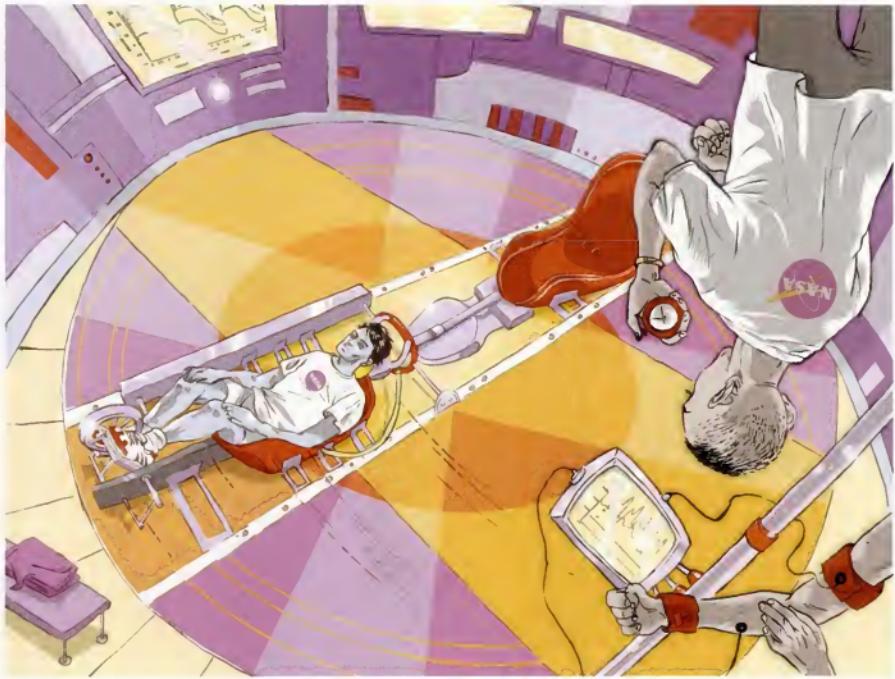


A SOLAR FLARE GIVES THE MAGNETOSPHERIC-PROPULSION SHIP A BOOST.

[PROPELLION]

THE BEKÜÖ (SEE PREVIOUS PAGE), WHICH POPULAR SCIENCE first covered in February 1999, uses the VASIMR system, which generates thrust by expelling ionized hydrogen gas and varies engine output—much the way a car's transmission does—to maintain efficiency. NASA engineers hope to test a prototype engine in space soon. The Mini-Magnetospheric Plasma Propulsion (M2P2) system (above), being developed at the University of Washington in Seattle, generates a magnetic field around itself with onboard magnets, then inflates this field like a bubble by pumping out ionized gas. Charged particles flowing out from the sun push on the magnetosphere like wind against a sail.—GREGORY MONE

Mars and the movies: www.popsci.com/exclusive



JONES PEDALS THE CENTRIFUGE FOR A STINT OF BONE-BUILDING ARTIFICIAL G.

[HEALTH]

□ PICTURE THE IMPACT OF A 50 PERCENT LOSS OF BONE MASS DURING A THREE-YEAR MARS MISSION: Astronauts could come back to Earth with brittle or broken bones, barely able to walk. On Earth, bones are always deteriorating, but in response to the stress of walking and other activities, they absorb calcium from the blood and build back up. But when gravity is absent (as it would be in transit to Mars) or reduced (as it would be on the Red Planet's surface), there is insufficient stress to bones, so they do not rebuild.

One solution is to create artificial gravity conditions in space with a centrifuge. An astronaut is strapped into a seat and the machine begins to spin, powered either by the astronaut's pedaling or by electricity. The rotation produces centrifugal force, which pushes the astronaut against the rim of the device, re-creating the stress of gravity. A centrifuge with a 5-foot radius would need to complete about 30 rpm to generate stress equivalent to gravity's pull on Earth and coax calcium flow to the bones. A larger centrifuge would produce the same effect with fewer

revolutions (hence the spacecraft-size centrifuge in *2001: A Space Odyssey*, which spun at a leisurely pace). NASA would prefer a small-radius centrifuge—something that could fit inside a spaceship. "Astronauts would go for a spin for a half-hour or an hour a day, like going to the gym," says Laurence Young, the Apollo Professor of Aeronautics at MIT's Man Vehicle Laboratory.

But there's a potential downside. At higher rotation speeds—30 rpm or above—many people experience motion sickness and disorientation. A simple turn of the head while rotating disturbs fluids in the inner ear, confusing the ear's vestibular system and creating a tumbling sensation. Young says, however, that his experiments have shown that after a few sessions, people adjust and can tolerate the movement without side effects. A beneficial byproduct of the centrifuge, in fact, may be that by training astronauts' bodies to switch back and forth between weightlessness and gravity, it will ease the transition to Earth upon their return. Now Young and Bill Paloski of NASA are enter-

ing a critical phase of the research, when they will collect data to determine whether centrifuge sessions succeed in diminishing bone-density loss in people subjected to long periods of bed rest, which can mimic the effects of low-gravity conditions.

Another potential bone-saver: an oscillating metal plate that delivers high-frequency, extremely low-magnitude vibrations to the lower legs. Astronauts would stand on it, like a scale. According to the plate's creator, Clinton Rubin, a professor of biomedical engineering at the State University of New York at Stony Brook, high-impact activities like walking and running aren't the only ones that build bone; small motions like postural sway are also key. Rubin's device simulates those low-intensity interactions between bone and muscle. In tests on sheep, Rubin found that daily 20-minute sessions on the plates boosted bone mass in the animals' joint areas by 34 percent. Rubin says astronauts could conceivably strap themselves onto the vibrating plate for 10 or 20 minutes a day to revivify their bones.—GREGORY MONTEITH

[SURFACE]

AFTER AS MANY AS NINE MONTHS in confinement en route, the crew will be relieved to get out and do some field work. Astronauts will cruise around near the base in open-top rovers (A), powered by fuel cells or photovoltaics, that were dropped off by an earlier Mars supply mission. For longer sorties, NASA plans to develop pressurized rovers capable of eight-hour jaunts.

Next-generation space suits (B) will be much less rigid and cumbersome than the current fashion, which is designed mostly for zero-G activity. Astronauts might wear peel-off films that would allow them to discard dust-coated outer layers of their suits before entering the habitat. New drills and burrowing probes will be used to search for subsurface water at base camp. Near the Martian ice caps, robotic thermal probes (C) will dig down to study the composition of Martian water. To power surface activities, NASA might need a nuclear reactor, which for safety would be installed up to a kilometer away from the main base.

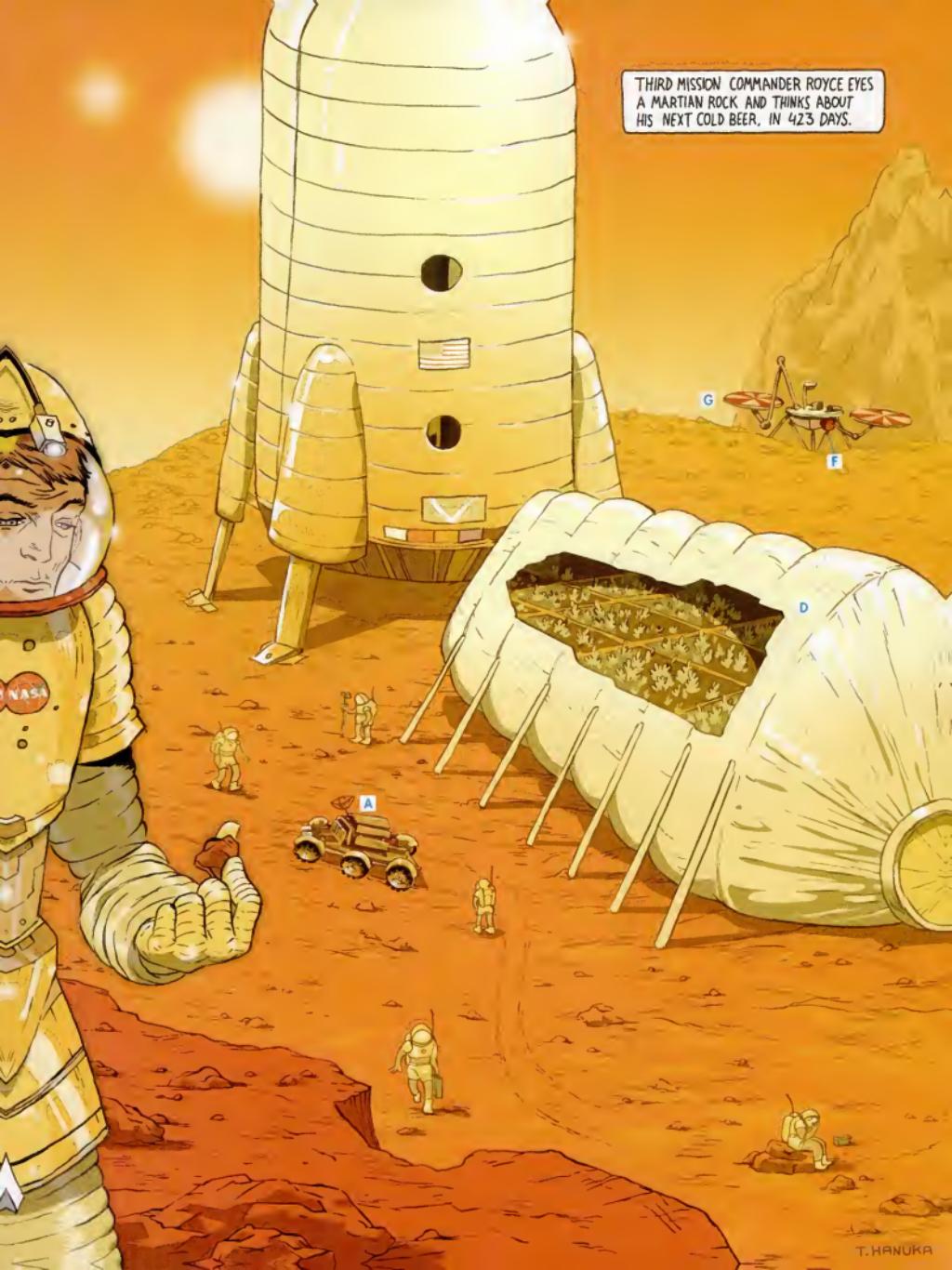
Conserving energy and resources will still be critical, though, so NASA is sponsoring research on building recycling systems for air, water, waste and power. The NASA Specialized Center for Research and Training in Advanced Life Support at Purdue University is developing a system that uses tiny, spherical balls coated with waste-eating microbes. Wash water, and possibly water separated from urine through freezing and other chemical processes, would be channeled down from the top; the microbes would consume contaminants, leaving astronauts with clean water at the bottom. Air could also be recycled through the system. The microbes would degrade organic contaminants as the air travels up from below.

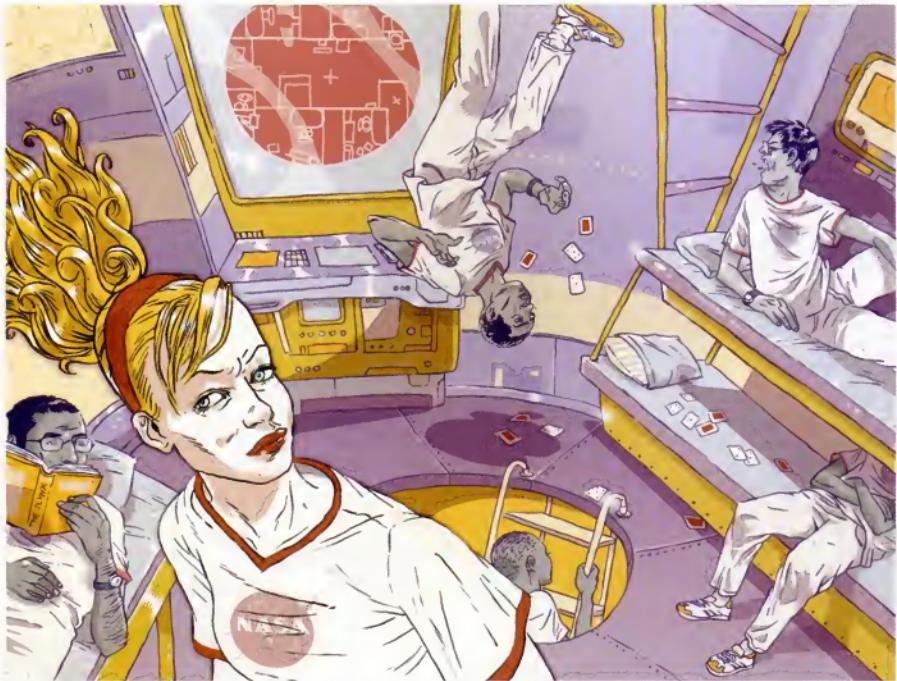
NASA-Purdue researchers are also working on energy-saving LED strips for plant growth. These "lightsicles" would illuminate from the bottom up, with each new light switching on as the plant grows. They could be used in an inflatable greenhouse (D), or, to protect plants from surface storms, in Martian caves or synthetic berms.

The crew pictured here isn't the first to land on Mars: The launch structure of a prior mission's ascent vehicle—which lifted off the planet and linked up with an orbiting Earth-return craft—remains (E). The exit fuel was produced on Mars, thanks to a converter (F) like the one now under development at Pacific Northwest National Laboratory. This device reacts atmospheric carbon dioxide with stored hydrogen to produce methane fuel and water. Through electrolysis, the water can then be separated into oxygen and hydrogen—the latter goes back into the conversion process. The converter would be the size of a basketball; it would be powered by a solar generator (G). —GREGORY MONE



THIRD MISSION COMMANDER ROYCE EYES
A MARTIAN ROCK AND THINKS ABOUT
HIS NEXT COLD BEER, IN 423 DAYS.





KEEP COOL, SUGAR: 17 MONTHS AND COUNTING WITH THESE GUYS COULD DRIVE YOU SPACE-CRAZY.

[CREW PSYCHOLOGY]

LENGTHY CONFINEMENT AND THE isolating sensation of being out of eyesight of Earth could unbalance astronauts' mental stability, psychologists say, making them morose and combative. In the enclosure of a Mars capsule, feuds, suicide, even murder could play out, endangering all aboard.

To estimate levels of psychological stress on a Mars mission, Russian space scientists plan next year to lock six cosmonauts in a 4,500-square-foot imitation spacecraft for 500 days, with limited amounts of water, food and oxygen. If the space module has to be opened early—for example, if a crew member has to be evacuated because of behavioral problems—it "would be considered a defeat, as if that person had died," Dmitry Malashenkov, a scientist at the Institute for Biomedical Problems in Moscow, told Agence France-Presse.

Other researchers are looking for ways to detect and treat psychological symptoms before they become too serious. Scientists with the NASA-funded National Space Biomedical Research Institute—a consortium of

12 institutions—are studying two types of physiological responses thought to be early indicators of stress: changes in facial expressions and in voice-onset time (the interval between when speech muscles contract and when sounds emerge). They plan to devise unobtrusive monitoring systems that could be placed throughout a spacecraft. These systems would track astronauts as they went about their daily activities and alert them—or the ship's doctor—to subtle but telltale changes in facial expression or speech.

David Dinges, director of the Experimental Psychiatry Unit at the University of Pennsylvania School of Medicine, is heading the facial-recognition study. Dinges' team puts subjects through a series of increasingly difficult and nerve-racking brain-teasers, giving them harsh feedback when they fail. As the subjects' stress levels rise—as measured by their cardiovascular and other physiological responses—video cameras record their faces. Computer scientists then create a mathematical "mask"—a digital face—from the video images. The mask highlights minute distor-

tions in a face's normal matrix and produces searchable numerical patterns to represent them. Next, Dinges' team plans to develop databases of facial expressions of people experiencing depression, inappropriate anger and other psychological disturbances. "We don't care so much about a specific emotion expressed in the face as much as detecting which tiny facial movements healthy individuals make when they're under a particularly difficult stress load," says Dinges.

By 2008, it may be possible to test a system like Dinges' in an all-in-one simulation facility to be built at Johnson Space Center. NASA earmarked an initial \$2 million this year for the Integrated Human Exploration Mission Simulation Facility, which will include a transit module, a surface habitation structure and a landing vehicle for the descent to Mars. Groups of astronauts will be confined there for months at a time to simulate a Mars journey in ultra-realistic detail, including delays of up to 20 minutes when astronauts communicate with Mission Control. —JEFFREY ROTHFEDER

(CONTINUED FROM PAGE 64)

than 6 million pounds on liftoff. This sort of rocket wouldn't be practical for carrying humans to Mars. The fuel required to travel 200 times farther than the Moon in a spacecraft the size of a small apartment would weigh so much that propelling the vehicle out of Earth orbit would be impossible.

The agency has requested \$3 billion over the next five years for Project Prometheus, a plan to explore new power and propulsion systems. Two unmanned vehicles will be first: a nuclear-electric-powered craft slated for a Jupiter mission in 2011 or beyond and a new kind of radioisotope-powered vehicle for a voyage to Mars in 2009. Another possibility is the Variable Specific Impulse Magnetoplasma Rocket (VASIMR) system under development at NASA's Advanced Space Propulsion Laboratory; installed in a craft tentatively called the Bekuö, it would use hydrogen fuel to race a crew to Mars in 90 days, one-third to one-half the time the trip would take with today's technology (see "Propulsion," p. 64).

No matter what type of engine is chosen, it's likely that the huge Mars vehicle would have to be constructed in space: Much less power would be required to propel the craft out of Earth's orbit than off the ground. The construction of the International Space Station proved that this approach is feasible, but to make space assembly cost-effective, NASA will need a shuttle replacement that can inexpensively and reliably ferry components into orbit. Once on Mars, astronauts will need a power source to run life-support systems and support exploratory activities. If lightweight solar-cell technology doesn't advance significantly, NASA may have to go nuclear.

RADIATION // According to recent measurements taken by the 2001 Mars Odyssey spacecraft, which has been orbiting Mars for two years, astronauts on Mars will be exposed to radiation levels of 20 to 25 millirads per day—twice the dose allowed for workers at U.S. nuclear power plants. Moreover, radiation levels will be even greater on the flight to and from Mars. Space radiation—energy and particles emitted mostly by the sun and other stars—can harm or sever strands of DNA in human cells, triggering cellular changes that over time can cause leukemia and other cancers. The body has DNA repair mechanisms, but elevated doses of radiation could cause genetic damage at a rate that outstrips natural safeguards.

Scientists have also become concerned that high-energy cosmic rays, which are much more prevalent in space than on Mars or Earth, could deliver radiation doses high enough to cause acute damage to the central nervous system, potentially

[MARS, WHEN?]

THE STALLED SHUTTLE PROGRAM, SETBACKS AT THE SPACE station, a lack of political will and public enthusiasm, not to mention the anticipated \$50 billion to \$200 billion price tag—these are some of the immediate obstacles to a manned Mars mission. We ask experts when they think we'll get there.

By 2020 **ROBERT ZUBRIN**, president of the Mars Society
"If NASA had been allowed to continue its Apollo program, the first children born on Mars would be entering junior high right now."

2025 **REP. NICK LAMPSON**, (D-Texas)
"We can get there 20 years from the time we make the commitment. We need someone to give us the vision."

2035 **BUZZ ALDRIN**, Apollo 11 astronaut
"We went from the Wright brothers to the Moon landing in 66 years. It shouldn't take longer than 66 years between the Moon landing and [getting to] Mars."

2050 **JOHN CHARLES**, Senior staff scientist at NASA's Space and Life Sciences Directorate
"Before February 1 [the Columbia disaster], I might have said we'd get there in 20 years. Now I'm in a more cynical mood."

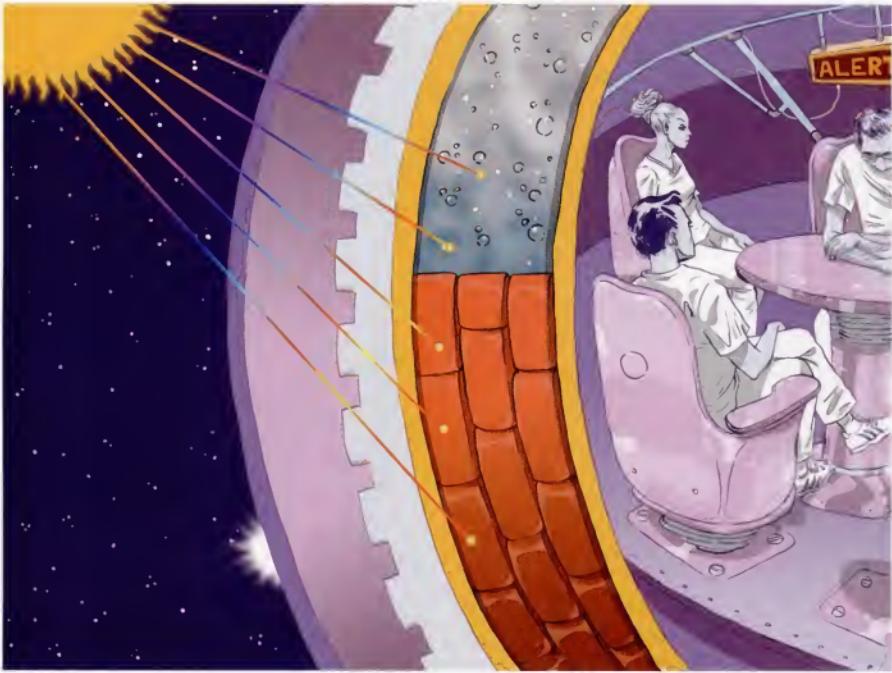
2075-2100 **ROGER LAUNIUS**, chair of space history at the National Air and Space Museum, Washington, D.C.
"We went to the moon for specific political reasons—Cold War crises such as Sputnik and the Bay of Pigs. What political crisis can one envision today to which the appropriate solution would be to open the coffers of the treasury and go to Mars? I can't really think of one."

Won't guess **GARY MARTIN**, NASA Space Architect
"People who think you can go there now are extremely optimistic. It's a whole new environment for us, and not a very hospitable one."

impairing astronauts' motor and cognitive abilities during a mission. And two years ago, a NASA study found that long periods in space boost an astronaut's risk of cataracts—likely an effect of radiation exposure. Due to radiation risks, NASA doesn't permit astronauts to spend more than 250 days at a time in space—hardly enough for a Mars voyage. One option: designated refuge areas within a Mars spacecraft in which the walls would be insulated with radiation-absorbing materials to protect astronauts during solar storms (see "Radiation," p. 70).

OTHER MEDICAL CONCERN // On long space flights, astronauts' bones thin, much as if they were suffering from osteoporosis, at a rate of 1 to 2 percent per month (see "Health," p. 65).

THE ISOLATION OF A MARS CAPSULE COULD PROVOKE FEUDS, SUICIDE, MURDER.



SOLAR STORM! NASA WARNS THE CREW TO REMAIN IN THEIR RADIATION-SHIELDED QUARTERS.

[RADIATION]

EXPOSURE TO RADIATION HAS ALWAYS been a significant worry for manned spaceflight, but until recently much of NASA's research has focused on the likelihood that it would boost the risk of cancer in astronauts years after they return home. Lately, though, the agency has begun to focus on another disturbing possibility. A concentrated dose of an unusual type of radiation—streams of heavy elements such as gold and silicon, known as high-energy cosmic rays, that race through the universe at near light speeds—could have an immediate impact on astronauts, and jeopardize the mission.

Scientists worry that high-energy cosmic rays could damage the genetic material in astronauts' brain cells, triggering a die-off that results very quickly in cognitive problems. A crew surgeon on a Mars mission could have trouble recalling medical procedures, or a field scientist might forget the route back to base camp during a rover expedition.

To address the new concern, NASA has established a \$30 million Space Radiation

Laboratory on the campus of Brookhaven National Laboratory in New York. Scientists there have already been using Brookhaven's particle accelerators, on a very limited basis, to fire beams of gold, iron, silicon and other heavy elements at cell cultures and animals; the new lab will give them full-time access.

In one of the experiments done to date, mice were shot with iron ions—a single dose, since cosmic rays are relatively rare. "To get a second hit in the same part of the brain, you'd need to wait about 100 years," says Marcelo Vazquez, the lab's associate scientist. Following exposure, the animals were monitored for changes in spatial memory. Mice that had been taught to recognize platforms in a small swimming tank were struck once with these simulated cosmic rays and then returned to the pool. Acute doses of 60 to 240 rads left some mice lost at sea.

In another experiment, Vazquez's team has been working with human neuronal stem cells—precursor cells that grow into mature brain cells when new memories are formed or

when existing brain cells are damaged. After bombarding stem cells with a cosmic-ray dose of about 10 rads apiece, they found increased levels of apoptosis, or cell suicide. The team also grew mature cells from the stem cells, then exposed them: At 25 rads they saw gene-expression changes and apoptosis. The human body may not respond to cosmic rays exactly the way the mice and stem cells did, but future experiments at the new Brookhaven lab will shed light on these processes.

NASA is also developing ways to shield astronauts from radiation during a Mars journey. One method is to insulate select walls of the spaceship with materials that have a high hydrogen content. Space weather forecasters would order the crew into a shielded area during a solar storm, where the hydrogen-rich walls would fragment and absorb intense radiation. Two possibilities: storing drinking and washing water within the cabin walls, and using polyethylene bricks, also high in hydrogen, to fill the gaps (see illustration above). —GREGORY MONE

Researchers don't know whether this process will slow during a long stint in zero-gravity conditions, but in a worst-case scenario, astronauts on a three-year Mars mission could lose as much as half their bone mass, leading to broken and slow-healing bones.

There's also evidence that the body's immune response is compromised during spaceflight. Studies of shuttle astronauts that compare their pre- and post-flight medical stats show decreases of as much as 50 percent in neutrophil activity—an initial line of cellular defense against illness. But these tests were done on the ground; NASA scientists aren't sure how the human immune system reacts to long periods in space. To find out, they are adapting standard immunology tools, such as the flow cytometers that monitor immune response by tallying immune cells, to operate in microgravity. A weak immune response would render astronauts vulnerable to infections they might normally stave off. Latent viruses could reactivate: An astronaut who had had chicken pox as a child and still harbored the varicella-zoster strain of herpes virus could develop shingles. By identifying potential health problems earlier—perhaps with nanoscale "molecular beacons" that would reside inside an astronaut's cells, acting as early warning systems—appropriate drugs could be taken before an illness set in.

Psychological Problems // Long-term confinement in the close quarters of a spaceship followed by the overwhelming isolation and loneliness of Mars—a place so distant that

NASA hopes to design computer monitoring equipment that can detect rising stress levels and the onset of psychiatric dysfunction in individuals during a voyage.

The Martian Environment // Mars is cold: At its landing site in 1997, Pathfinder measured temperatures ranging from a high of minus 13°C to a low of minus 93°C during a single 24-hour period. It's also bone-dry. Seasonal dust storms could produce an electrostatic charge of as high as 8 kilovolts, enough to crash computers and blow fuses. The planet's unbreathable atmosphere is mostly carbon dioxide, and there is no surface water supply. It wouldn't be practical for astronauts to carry all the air or water needed for a multi-year journey, so they will likely bring converters capable of reacting the planet's carbon dioxide with stored hydrogen to produce methane fuel and water. Through electrolysis, the water could be broken down into breathable oxygen and hydrogen, which would be recycled back into the system (see "Surface," p. 66).

Risk Is the Wild Card. Although NASA is developing technologies to aid the voyage, some dangers will be impossible to anticipate. Dennis Pelaccio, a Littleton, Colorado, engineer who has assessed the risks of planetary missions for NASA, says that on early Mars missions the probability of safe return could be lower than 75 percent—a one-in-four chance that astronauts will die on the journey. Apollo-era risk assess-

POST-COLUMBIA, A 1-IN-4 RISK OF A MARS-MISSION DEATH REGISTERS OFF THE CHARTS.

there's a delay of up to 20 minutes in communications with Earth—could provoke conflicts among crew members and precipitate individual cases of depression and anxiety (see "Crew Psychology," p. 68). During a 1999–2000 isolation experiment at the Russian Institute for Biomedical Problems, a fight between two crew members ended with blood splattered on the module walls, and a female Canadian astronaut complained of an unwanted sexual advance by one of her Russian colleagues. NASA will be studying such confinement in its soon-to-be-built Mars simulation facility at Johnson Space Center.

Since there is no parallel for the extreme psychosocial conditions that would exist on a trip to Mars, it's difficult for NASA scientists to accurately predict how astronauts will cope. The agency is investigating whether it can limit harmful disagreements on board by soliciting a wide range of personality types, not just the stereotypical Type-A astronaut. Options include teaming husbands and wives or picking astronauts with dissimilar behavioral types—some assertive, some compliant. An even bigger worry is the possibility of severe bouts of depression during a Mars flight, which could diminish the ability of astronauts to perform critical tasks, thus endangering the mission and other crew members.

ments predicted similar success rates, and the first Mars trip will be much longer and more complex than Moon missions.

In today's post-Columbia era, with some in Congress insisting that the shuttle's 98 percent success rate isn't good enough, the Mars risk is off the charts. Nevertheless, Pelaccio insists, his estimates reflect reality. "A Mars voyage is not a routine shuttle flight," he cautions. "You have X amount of risk and Y amount of resources, and over time you try to buy down that risk with research and new equipment. But there are no certainties, and you're fooling yourself if you think there are. To do true space exploration, NASA and the people of this country will have to accept higher levels of risk."

With all its obstacles and risks, a Mars journey is an endeavor that illustrates the core purpose of NASA—taking humans to places we've never been. It's the highest form of adventure, and it's scientific research at its most innovative. The question left to answer now is not whether we should go to Mars, but whether NASA is far-sighted enough to take us there. ■

James Oberg, an author and a consultant on spaceflight, worked for 22 years at Mission Control in Houston. He is the NBC News analyst for the investigation of the Columbia shuttle disaster.

BULLET 1



GRENADE



BULLET 2



LIGHTS, CAMERA, NANO- SECOND ACTION



HIGH-SPEED
MOVIE
CAMERAS
CAN SHOOT
UP TO
20 MILLION
FRAMES IN
THE BLINK OF
AN EYE.
THE WORLD
IS A MIGHTY
INTERESTING
PLACE IN
ULTIMATE
SLO-MO.
BY ETHAN
SMITH

• **BULLET 1** .22 caliber bullet fired through aluminum, shot at 500,000 frames per second (fps).

- **GRENADE** Electronically triggered detonation captured with a Model 126 Rotating Mirror Framing Camera capable of up to 20 million fps.
- **BULLET 2** .22 caliber bullet hits a sheet of glass edge-on at 500,000 fps.

IN THE CLIMACTIC GUN BATTLE OF John Woo's deliriously nutty identity-switch action film *Face/Off*, the two enemies—Cage and Travolta—and their sidekicks fire away at each other with Berettas and Glocks; you can see densely detailed plumes of smoke erupt from the muzzles, obscuring the shooters' hands. As bullets emerge from weapons, thousand-foot-per-second velocities slow to a graceful glide, until the spin from the spiral rifling of the gun barrels is clearly visible. It looks like a beautiful bit of computer-generated-image graphics—less fancy than the ripple-wake, stop-dead bullet magic in the new *Matrix* movies, but somehow more real.

That's because the Woo images are more real than CGI: Real bullets were slowed on film by a one-off, hand-built device called the Millisecond Camera, shooting 12,000 frames per second. For all the advances in digital effects, 35mm film still offers more information for the eye: "When you really look at it, you can tell it's film," says Nathan Nebeker. "You just don't get that richness of detail with CGI." Nebeker knows what he's talking about. He is the owner of a company called Connexion Films, and he made the Millisecond Camera.

Nebeker's camera bears scant resemblance to standard movie cameras. "You couldn't make a mechanical shutter open and close quickly enough," he says. "[And] there are physical limits to how fast you move film through a camera. To go really fast, you have to move the light to the film." In his camera, a loop of film rotates rapidly in a drum, whose housing is emptied of air to reduce friction. A rotating mirror and a series of optics directs a "slice" of light to each frame. At speed, the camera holds only enough film for a hundredth of a second's worth of action, but that's not quite the problem it sounds: A bullet flies 10 feet in that time.

But the most extraordinary thing about the Millisecond Camera may be this: In Nathan Nebeker's world, 12,000 frames per second is an excruciatingly slow clip. Running Connexion Films is Nebeker's second job, a Hollywood- and TV-focused spinoff of the family business: building *really* high-speed movie cameras. Cordin Scientific Imaging, based in Salt Lake City and headed by Nathan Nebeker's father, Sid, has been in the sometimes secretive service of the scientific and military community for almost 50 years. The fastest cine camera produced by Cordin today is unimaginably quick: One second of images taken with the 200-million-frames-per-second digital model would take 96 days to view if played back at standard movie speed.

PICTURING THE BOMB

High-speed still photography dates back decades, most famously to the spectacular milk-drop and bullet-through-apple photography of Harold

Edgerton, who invented the strobe in 1931. Very high-speed movie photography started later, and came into its own as a scientific tool in the birthing room of the atomic bomb. Its purpose has been not so much to freeze a moment in time, but to glimpse what changes from one infinitesimal moment to the next. It begins at the point at which our familiarity with ordinary time-splitting ends, a point not far past the 100 milliseconds that constitute the blink of an eye. Ordinary cameras freeze time, but crudely and in big chunks. Movie cameras fool the eye into seeing continuous motion when only 24 still frames are presented per second. We know from snapshot experience

FIRST FAMILY OF HIGH-SPEED MOVIES

Below: Cordin patriarch Sid Nebeker with son James and daughter Trindi.

Opposite: The main machine shop and R&D area, and two views of a Model 126 rotating-mirror camera.



WHAT DOES SPACE DEBRIS DO? ▶

Sequence opposite, taken by NASA at its White Sands Test Facility, shows

the effect of a 6mm stainless steel projectile blasted into space-station-grade aluminum at 6.66 km/second. Shot with a Cordin Model 140 camera.

that the $\frac{1}{500}$ th or $\frac{1}{1,000}$ th shutter setting will stop most human motion. Beyond this realm—into micro- and nano-dimensions of time, let alone across exotic picosecond and femtosecond frontiers—the very fast is almost as invisible to us as the extremely small. The eye does not register, and the conventional camera does not record.

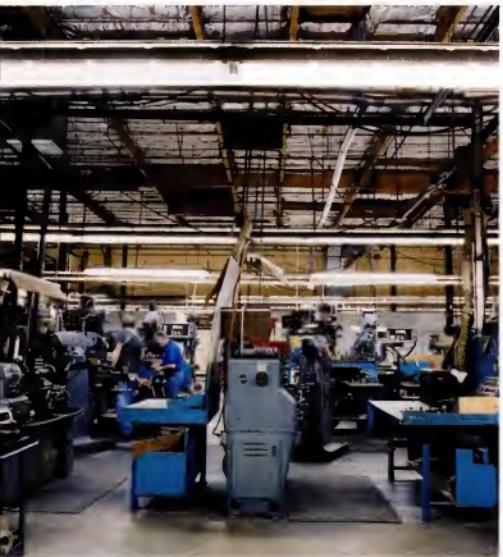
High-speed movie cameras do record, but many of the most arresting picture sequences taken with such equipment have not been seen—except by a few researchers who might go to jail if they released them to the public. Secret weapons research is in the DNA of this business.

During the final stages of the Manhattan Project, Los Alamos scientists hit a brick wall. Sid Nebeker recalls hearing an account of this little-known chapter in history from Berlyn Brixner, a technician who still lives quietly, at the age of 96, in Los Alamos. The scientists who were developing the theoretical and practical framework for implosion weapons hadn't been able to get them to work properly. There was much disagreement about whether that failure meant that the entire concept was flawed, or merely that the execution needed adjustment—perhaps, for example, the shape of the explosive "lens" that was supposed to trigger the nuclear reaction needed to be modified. Brix-

ner, NACA. "With Miller's concept of forming the image on a rotating mirror and putting a sequence of lenses between mirror and film, you can jump to 1, 2 or 5 million images per second," says Sid Nebeker. "Extremely crisp ones at that."

There was room only for a short bit of film, of course: The camera could shoot only 24 frames. But you could time exposure within a tenth of a microsecond, an interval so precise that when the test failed again, scientists had a frame-by-frame record of the event.

"Brixner's camera was like a ray of light into a very dark situation," says Nebeker. The problem indeed lay with the uneven detonation of the con-



CLOCKWISE FROM TOP RIGHT: COURTESY NASA JSC
WHITE SANDS TEST FACILITY; KEVIN ZACHER [3]

HYPER-VELOCITY IMPACT TESTING



ner was enlisted to capture the footage that would allow the scientists to see what was happening.

The camera Brixner used was an early rotating-mirror design. A mirror in the center of a cylindrical housing projected images in series from the camera's main lens to the film, which was seated along the inside edge of the housing. The light traveling to each frame passed through its own set of lenses en route. The mirror acted as a sort of shutter, flashing a discrete image onto the film and forming a discrete frame. This design had been adapted from work done by C. David Miller, an engineer who worked at NASA's prede-

vventional explosives. A movie camera cleared the final serious obstacle in the path to the atomic age.

The original Cordin camera, built in 1956 shortly after the Manhattan Project technology was declassified, and capable of 1.25 million frames per second, was based on the same rotating-mirror design—a design that is still at the heart of the company's biggest, most expensive machines.

High-speed camera manufacture has always been a small, clannish industry serving a highly specialized academic community—shock-wave and cavitation physicists, hypersonic-aviation researchers, materials scientists interested in the

dynamics of fractures, cracks and vibration—as well as the military research labs working on “energetic materials,” ballistics, bombardment and bombs. The most recent biennial conference of the trade’s worldwide professional organization, the International Congress on High Speed Photography and Photonics (which includes all forms of high-speed imaging, still and moving), had just 226 attendees. Much work involving high-speed cameras continues to come out of labs such as Los Alamos and Lawrence Livermore, with their deep roots in military-tech research. And much of the photography contin-

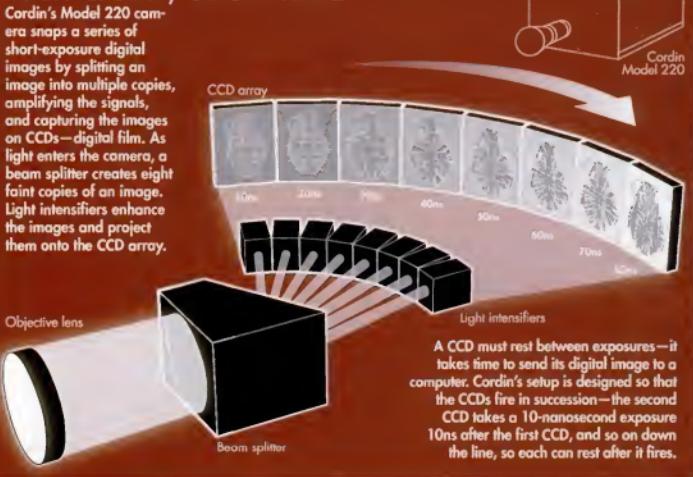
ues for more than \$200,000. The end user turned out to be Al Kindi General Establishment, an Iraqi weapons lab involved in nuclear research. Export license denied. “After the first Gulf War,” Sid Nebeker relates, “they found [in Iraq] some Japanese cameras that would have been somewhat helpful. But they wouldn’t have provided nearly the crispness or speed of ours.”

HAND-BUILT FROM SCRATCH

Sid Nebeker has been running the Cordin company since the early ’60s, when he bought it from its founders, both of whom had been his class-

SPLIT LIGHT, STOP TIME

Cordin’s Model 220 camera snaps a series of short-exposure digital images by splitting an image into multiple copies, amplifying the signals, and capturing the images on CCDs—digital film. As light enters the camera, a beam splitter creates eight faint copies of an image. Light intensifiers enhance the images and project them onto the CCD array.



BRIDGEWIRE

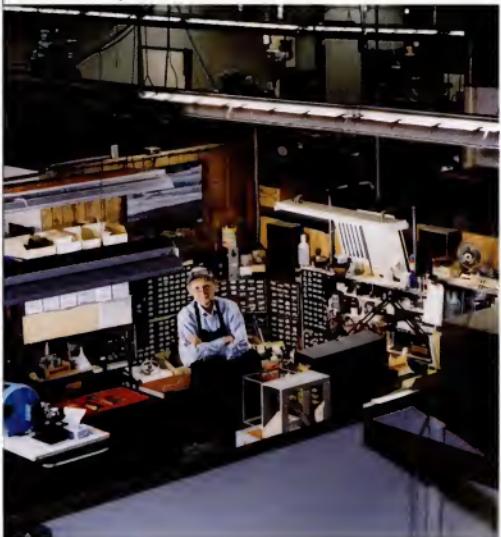
ues to be secret—not only for security reasons but because a car company studying, say, combustion efficiency in an engine fitted with transparent cylinder heads keeps competitive data to itself. “I think I saw some stills [of weapons research] once in a slide show at a conference,” Nathan Nebeker says. “That’s as close as I’ve gotten to seeing the footage.”

The international market is constrained as well: Cordin cameras must be licensed for export by the Department of Energy, which regulates technology related to nuclear weapons. In 1990, an import-export firm located in New Jersey approached Cordin to try to buy one of its cam-

eras at the University of Utah. Cordin’s headquarters are located in an industrial section of Salt Lake City, far removed from the gleaming downtown familiar from Olympics coverage. Cordin, which today has about 30 employees, resides in a large, low warehouse that’s divided into an area of spare offices and a sprawling workshop. The office decor is unrelieved engineer-drap: wood-grain paneling, linoleum flooring and, in some rooms, ancient wall-to-wall carpeting.

I found the senior Nebeker in the engineers’ work space, standing, sleeves rolled up, beside a young engineer at a workbench, the two of them tinkering with the circuitry in a camera headed for

HOW FAST WOULD YOU LIKE THAT?
Electrical engineer Steve Holman is part of the team that developed the new-generation Series 500 rotating-mirror CCD cameras, capable of 200 million frames per second.



◀ JUICE!

Images on the left show how a 28-gauge stainless steel bridgewire—used to detonate explosives—becomes plasma after 5 kilivolts of electricity is applied. Cordin's Model 220 camera used sequential exposure times of 10 nanoseconds, or 10 billionths of a second.

in the Air Force, attended Harvard Business School, then returned to Salt Lake City in 1958 to look for work. "There were limited opportunities in Utah for a business-engineering major," he says. Nebeker spent six months at a fledgling technology company that was going nowhere. In 1959 he met an engineering school classmate named Earl Pound. Pound was part of the faculty at Utah State University and had formed Cordin a couple of years earlier, when the Manhattan Project camera technology was declassified. Cordin had made just one product, the 1956 camera that the Navy bought for use at a weapons facility in Maryland. Since then, Cordin had been dormant: no

employees, no customers, no business plan.

Nebeker proposed that the company be restarted, then spent several months at Cordin without pay. He perfected the original camera design, making it "extremely reliable and extremely accurate." Several months later an order came through from the China Lake Naval Weapons Center, in California. Weapons development is, within the club, a word-of-mouth business, and the camera, along with the China Lake technician who operated it, "became our sales force for the next four or five years. People from the defense industry would call to inquire about our cameras, and we'd say, 'Talk to Roland Gallup at China Lake. He's got one.' He was a marvelous photographer. They'd talk to him and he'd show them some of his work and they'd be sold." (China Lake still uses Cordin cameras.)

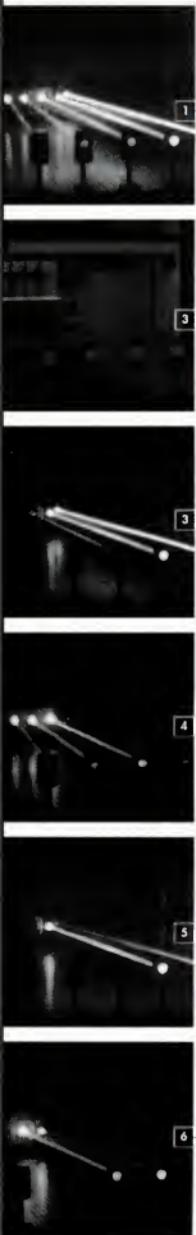
Cordin was off and running in a small niche of the high-speed photography business, though it turned out not to be a very high-speed business; the company today sells about 10 cameras a year, often customizing for specific jobs.

The chief customizer is James Brimhall, 70, who has been with Cordin for almost 20 years and is in charge of camera assembly. The work is as much about handcrafting as engineering. Cordin's own shop fashions practically every knob, gear and fitting for each camera. With his shop apron, hat, glasses and two hearing aids, Brimhall has an old-world, master-craftsman mien, and is now passing on his expertise and responsibilities to a 32-year-old employee named Lane Oberg. For Oberg, it's a matter of learning by doing: One does not arrive from optical-engineering school ready to build a device as specialized as a Cordin camera.

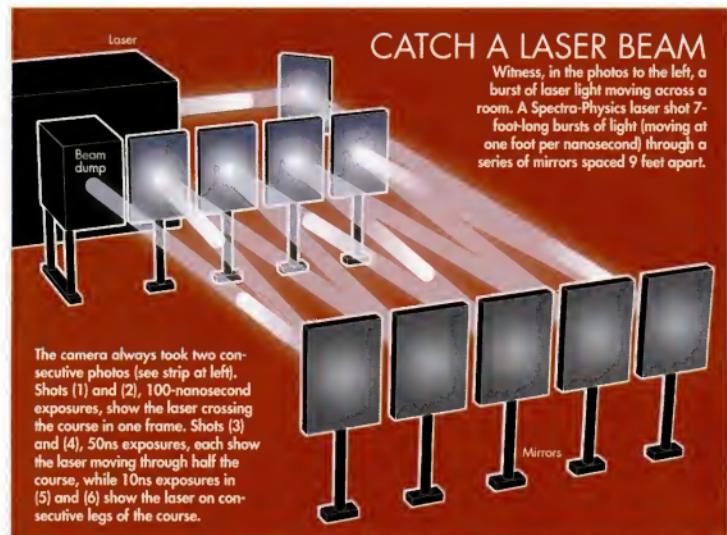
One morning I help Oberg assemble one of 160 lens housings that will form the guts of a \$385,000 rotating-mirror camera destined for a ballistics range at Los Alamos National Lab. It will be the fifth Model 140 camera the company has built in its history: 2.25 million fps, f/16 aperture, 80 frames total. Its mirror is a pentagonal lump of beryllium coated in polished aluminum; the beryllium has been X-rayed to ensure that the crystalline structure is pristine, lest it explode when rotated at 562,500 rpm by the camera's helium-driven turbine.

Oberg greets me from his desk, where he's holding a black, anodized-aluminum mount in one hand and an electric Dremel tool—the kind you see advertised on late-night TV—in the other. Metal shavings are piled on the floor nearby. "I knew there was a reason I kept this thing around!" Oberg says cheerfully. "Never used it before, but I figured it'd come in handy."

He then begins grinding away at parts of the mount, exposing the silvery metal on several surfaces. He explains that the hundreds of lenses that go into the camera will be held in place by these mounts, which are precisely engineered to strict tolerances. But the cement he's using to hold the



SPEED OF LIGHT



precision-fit lenses into an assembly that's clamped to the workbench. Placing them turns out to be easy enough, gluing them even easier. Just squirt a dollop of cement through an 18-gauge needle, then shine a high-intensity ultraviolet spotlight on it for a few seconds—roughly the same way a dentist cures an epoxy filling.

WHEN MICROMETEORITES HIT

At 5,000 frames per second you can see a place kicker's foot connecting with a football as the

pigskin slowly wraps around his instep. "To see a golf ball," says Nathan Nebeker, "you're up to 12,000 frames per second," because the club is accelerated to terrific speeds by the lever action of the swing. The next order of magnitude, hundreds of thousands of frames per second, allows you to observe fairly high-speed events: Toyota used a rotating-drum Cordin camera capable of speeds of up to 200,000 frames per second to peer into its see-through engine. The French navy bought a similar camera, along with a special water-sealed periscope designed and built by Cordin, to observe the effects of explosives striking ships' hulls.

But when an object strikes a barrier at 16,000 mph, you need sequences shot in the million-fps range to study the violent effects: Hence the Cordin camera at NASA's Hypervelocity Impact Test Facility in White Sands, New Mexico, where scientists blast space-vehicle components with tiny projectiles to simulate what happens when they are hit by fast-moving space debris (bits of satellite hardware that have come loose, paint chips) and micrometeorites.

About 100 times a year, [\[CONTINUED ON PAGE 102\]](#) ▶



A speed-of-light photo made with different technology, from PopSci 50 years ago: www.popsci.com/exclusive

1¢ Calls

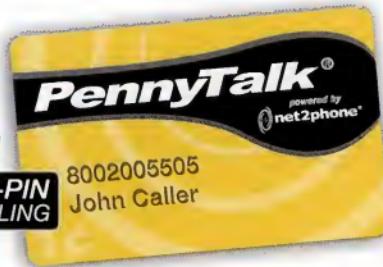
Anywhere in the U.S. – 24 hours a day

The **PennyTalk®** Calling Card is for real.
It features **No-PIN Dialing** - quick, direct,
fast, without lots of numbers to dial.

PennyTalk® with No-PIN Dialing lets you connect fast from your favorite phones. At **1¢ a minute** in the U.S., and as low as **2¢ worldwide**, your pennies really count. And a small 49¢ connection fee makes PennyTalk one of the best values in calling cards today.

NEW!

**No-PIN
DIALING**



- Same low rates 24/7
- No monthly contracts or obligations
- International calls from your cell
- Keep your current phone company
- Toll-Free live customer support
- Automatically add minutes – not a throwaway card
- Just a low 49¢ connection fee

Get Your Instant Card Now. Start Saving Today.

1-888-429-8109

www.PennyTalk.com

NEW LOW RATES

Call Over 250 Countries For Pennies

Canada	2¢	São Paulo	4¢	Mexico City	6¢	Netherlands	2¢
U.K.	2¢	Warsaw	5¢	Prague	2¢	Johannesburg	10¢
Germany	2¢	Spain	2¢	Ireland	2¢	Israel	6.9¢
Moscow	2¢	Buenos Aires	6¢	Sweden	2¢	Milan	2¢
France	2¢	Australia	4¢	Lima	7¢	Switzerland	2¢

49¢ connection fee charged at the time call connects. Cellular and payphone surcharges may apply. 99¢ monthly service charge. Initial minimum debit or credit card charge of \$15 required for this offer applies to calls. No-PIN Dialing available for up to five phones. Rates subject to change without notice. Check www.getpennytalk.com for current rates and terms of use. PennyTalk®, Net2Phone®, and all related logos are trademarks of Net2Phone, Inc. ©2003 Net2Phone, Inc. All rights reserved.

First patented dish antenna brings in broadcast signals other antennas can't find.

The XiumAir's® Spilateral technology conquers ghosts, fuzzy pictures and rooftop monstrosities.

If you live in an area where TV reception is weak, 'rabbit ears' and ugly rooftop antennas may only bring in fuzzy signals that aren't worth watching. Enter the XiumAir Antenna -- the world's first spilateral antenna designed to bring in strong video and audio signals from all directions for great TV/stereo reception. Patented spilateral technology lets the XiumAir grab signals coming from all directions from as far away as 50+ miles. Its 18" parabolic reflective / ground element increases signal strength and stability to give you local broadcast reception as good as, or better than, cable TV or satellite reception. There's no expensive installation required, and it's fully compatible with any TV or stereo tuner for high-energy VHF / UHF / FM reception.

No aiming, rotating or tuning.

XiumAir's new 83-channel technology combines an all-in-one device for receiving high-energy TV reception. Unlike most external antennas, the XiumAir doesn't have to be pointed in the direction of transmitters. That's the beauty of spilateral technology. You can mount the dish-like antenna indoors or outside (on your roof or a horizontal mast). The higher the elevation,

The world's first dish-type TV antenna - the last antenna you'll ever need

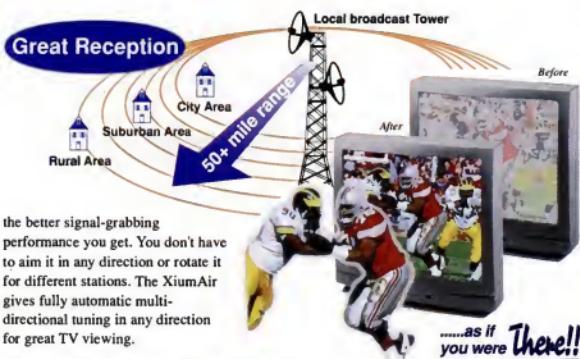


- NO MORE HUGE, UNSIGHTLY ROOFTOP ANTENNAS
- CLEARER PICTURE AND SOUND



XiumAir® Works!

No matter where you live, the Xium air spilateral "dish" antenna will collect all of the signals available, from any direction without the need for rotating or tuning.



the better signal-grabbing performance you get. You don't have to aim it in any direction or rotate it for different stations. The XiumAir gives fully automatic multi-directional tuning in any direction for great TV viewing.

The versatile antenna with many uses.

If you have a DSS satellite system, the XiumAir is the ideal complement for receiving local channels without monthly fees. And when high definition broadcast TV arrives in a few years, you will be ready. Plus you can use the antenna now for AM / FM stereo, home-based CB systems, and shortwave radio. The XiumAir Antenna features compact, modern styling that will blend in with almost any decor. The UV-protected housing is made of impact-resistant copolymer, making the exterior resistant to weathering and color change. It includes a standard cable connector for any cable-ready hookup. The XiumAir Antenna delivers maximum local broadcast reception to any television, stereo or any other audio or video receiver, without the use of unsightly, ugly or 'wind damaged' antennas.

Enjoy better TV reception - risk free!

This unique design is the result of years of research and testing, and now you can try it for yourself risk-free. Each XiumAir Antenna System is handcrafted and individually tested



World's first dish-type TV antenna for great local reception

for high quality performance. With the XiumAir Antenna, you'll eliminate those unsightly antennas for good. The XiumAir Antenna comes with a 30-day manufacturer's limited warranty and Xium's exclusive risk-free home trial. If you are not satisfied for any reason, just call us for free expert installation assistance, or simply return it within 30 days for a full refund, less S&H.

Order Yours Today!

XiumAir™
Item# XMA201 \$129.95
plus \$15 S&H

Please mention source code: 10063

For fastest service, call toll-free 24 hours a day

800-342-3206



To order by mail, send check or money order for the total amount including S&H. To charge it to your credit card, enclose your account number and expiration date.

Xium
ANTENNA SYSTEMS

4720 N.E. 24th, Amarillo, Texas 79107

The Smart Garage floor plan includes a complete woodworking shop. Its linear layout, with mini-rollup door at one end, makes handling long lumber easier and maximizes productivity. The Gladiator™ GarageWorks system allows us to fully utilize the entire space. Glazed sliding doors separate it from while giving easy access to the gardening area.

2 Mighty but compact describes the variety of Ryobi benchtop tools that do the work of full-size shop equipment but don't block up valuable floor space. Professional features at affordable prices.

3 A second mini-rollup door opens to the garden area, where pro-grade Homelite gas-powered portable outdoor equipment hangs ready on GearWall™ Panels from Gladiator™ GarageWorks. A one-ton-capacity GearRack in back provides deep storage and does double duty as a planting area.

4 Talk about productivity—this brawny but beautiful John Deere X595 garden tractor has all-wheel steering, four-wheel-drive plus fore-and-aft hitches for powered accessories. The industrial “Lazy Susan” makes for a fast and easy turnaround. Handmade of steel tubing and expanded metal, it sits on heavy-duty casters for 360 degree mobility.

5 In our above-it-all multimedia lounge, light-absorbing particles embedded in the Research Frontiers' Smart Windows provide soft shade until you hit the switch—then the particles align to a state of instant clarity. Humanscale Saddle Seats offer compact comfort and an Actiontec wireless-ready cable/DSL router eliminates wiring for electronic tools and toys such as these Sharp notebook computers and Viewcam-Z digital LCD camcorders.

6 Road warriors need to be well armed, and Sharp Actius notebook computers are Wi-Fi ready and good to go. Slim, lightweight and travel-tough, they deliver all the power and features needed on the road or online. Here, they perch on adjustable, ergonomic Laptanage swivel stands.

7 Works hard, looks great—the Leatherman Juice Kf4 has needlenose pliers, straight and serrated blades, diamond file, saw, screwdrivers and more. In the shop, we reach for the Super Tool 200, the brawnliest multi-tool in the line.

8 Up in the break area, you can soak up the view from Sharp's AQUOS 30-inch HDTV-compatible Liquid Crystal Television with superb image quality and impeccable styling. Just over three inches thin, it delivers exceptionally bright, vivid colors and contrast, and an unmatched 170x170 degree viewing angle. It also makes a powerful statement on a wall or placed atop a table or shelf. Any way you look at it, the AQUOS is a superior alternative to plasma televisions.

9 The break area is equipped with a sink/wet bar and Gladiator™ GarageWorks® Freezerator™ Refrigerator-Freezer, which has a mini-fridge up above and lots of storage space in the maxi-size freezer below. Conversely, Sharp's over-the-counter microwave heats things up in a hurry.





SPECIAL ADVERTISING FEATURE



SMART GARAGE— SEE WHAT IT'S THINKING NOW...



PRESENTED BY:

GRAB LIFE BY THE HORNS



GLADIATOR
GARAGEWORKS
by Whirlpool Corporation

IT'S TIME TO RETHINK THE GARAGE.™

SHARP
be sharp™

©2014 Daimler AG. All rights reserved.

SMART GARAGE



SMART POWER

What began as a remarkable innovation in the car world has evolved into an awesome display of power.

We are talking about the 5.7L Dodge HEMI® Magnum. Truly a metaphysical work of art, the HEMI's high-compression action produces impressive power. The HEMI'spherical combustion chamber acts with a dual-ignition system and two spark plugs per cylinder for complete combustion. The result: up to 345 horsepower and 375 lb-ft of torque at your disposal.

Having a reputation for power, the re-engineered Cummins High-Output Turbo Diesel* produces 305 horsepower and 555 lb-ft of torque.



Simply put, the Dodge HEMI Magnum V8 and Cummins High-Output Turbo Diesel present a superior force to be reckoned with. Both are part of the most powerful line of trucks.

*Not available in CA, ME, and MA.

GRAB LIFE BY THE HORNS



DODGE





10 Our Sharp AQUOS is paired with a Sharp SD-AT50DV high-performance home theater system powered by 1-Bit Technology for the highest sampling rate available in digital audio. It's the perfect format for watching the mechanical mayhem of Junkyard Mega-Wars—the mega-horsepower version of TLC's original cult hit. A new format and over-the-top challenges will have gearheads tuning in to see the most awesome contraptions built entirely out of junk!

11 Rustic design and modern sensibility meld to create the space-efficient Kohler Arica bathroom fixtures, which make practical use of a compact space.

12 Where space is a premium, it pays to invest in organization. Gladiator™ GarageWorks offers everything you need to put things in their place. GearWall™ Panels with specialized shelves, baskets and hooks get bulky items up and out of the way. Wall GearBoxes can also hang on these panels. GearDrawers and GearBoxes roll out to bring tools to wherever you're working, then store under the Modular Workbench. Tall GearBox Lockers offer maximum storage space in minimum floor space.

13 Cordless tools are no longer a novelty, so battery recycling makes sense. RBRC counter boxes in stores provide free recycling bags for returning your worn-out batteries. Meet RBRC celebrity spokesman Richard Karn at the Smart Garage on Sunday, June 22, to learn more about the benefits of battery recycling.

14 A properly maintained fuel system is key to vehicle performance. Racing legend Richard Petty recommends STP fuel additive products to remove power-robbing deposits from fuel systems and to help avoid problems such as hard starts, lost acceleration and rough idling.

15 Details, details. Armor All Original Protectant's UV blockers slow vinyl aging, while premoistened Car Wash Wipes save time and safely protect clear coats, and Extreme Tire Shine locks in a long-lasting gloss finish to maintain sidewall appearance longer.

16 Garage floor paint just doesn't hold up under hot tires, road salts, petroleum and antifreeze compounds, and heavy wear, but Rust-Oleum EpoxyShield is impervious to all—and provides a showroom-quality finish.

17 Storer Invisible Glass cleans windshields, windows and mirrors so well, they appear to be invisible, and its nonabrasive formula evaporates completely.

18 Lutron lighting controls, like the Spacer remote control dimmer, replace ordinary wall switches and allow us to adjust the lighting from anywhere in the Smart Garage, even from a nearby vehicle.

19 Hungry? The multifeatured DCS barbecue grill with gas burners, rotisserie spit and infrared heating serves up a multitude of culinary wonders. Its durable stainless steel exterior looks as good as it cooks.

The Smart Garage is unmistakable to anyone who sees it, with its blaze red paint, dark metal roofs and bold geometric shape. But the innovations and features that make it smart are as obvious to the unknowing as a B-2 Stealth bomber is to a target.

Although it's designed to be a functioning, full-service home garage in every respect, even standing on the same-size footprint as your typical two-car garage, visitors entering it for the first time become instantly aware that there is far more to this structure than can be seen from the curb.

Unconstrained by conventional building requirements, its interior openness allows for two floor levels above the garage bay: A spacious midlevel mezzanine serves as an audio/video entertainment area, and another room higher up is optimally sized for an office, an apartment or—as we like it—an airy multimedia lounge for uninterrupted online sessions, digital darkroom processing and gaming.

Because the Smart Garage was built with strong structural insulated wall and roof panels, few interior supports were required and high-volume interior spaces were the result. Larger interior space equals more room to play: In addition to the double garage, mezzanine and lounge, there's a complete woodwork shop, and behind that a gardening center big enough to

park a tractor. Four rollup garage doors provide maximum access to all areas.

Innovative products make these spaces even smarter. A GladiatorTM GarageWorks system provides the cabinets, workbenches and even wall-storage components to keep clutter under control. New Wilsonart Tap-N-Lock glueless laminate flooring is tough on wear and tear but easy to install and clean. Catawba engineered-wood siding from Georgia-Pacific is as affordable as it is durable. Rows of skylights, energy-saving Progress Lighting fixtures and Lutron remotely controlled dimmers and switches give our garage maximum lighting flexibility and management.

The technology in the Smart Garage creates a supremely functional and enjoyable environment.

Research Frontiers' electronic "switchable" Smart Windows offer shade or views on command. Wireless Wi-Fi from Actiontec helps cut the cords whether we're up in the lounge or running engine diagnostics on the shop floor. A Sharp AQUOS 30-inch Liquid Crystal Television looks spectacular on the wall—even when it's not turned on.

The only thing that's obvious about this multidimensional structure is that it's perfectly suited to anything it needs to be. Car park, ultimate workshop/office, hideout? Whatever. The Smart Garage is thinking—and ready.



The smarts in the Smart Garage include the ultimate in sound and climate control. Our foam-insulated structure helps; however, the real commanders are our Dave Lennox Signature air conditioning system and gas furnace with SilentComfort technology—the quietest indoor-air systems you can buy. Typical AC compressors operate at around 80 decibels, which is 16 times louder. Equally important is our Dave Lennox Signature PureAir system, which gets rid of stinky shop odors, mold spores, mildew, airborne dust and potentially volatile fumes—with this trio in place, breathing is easy in the Smart Garage.



SMART GARAGE TOUR DATES

June 19-22

NASCAR

Winston Cup Series

Infineon Raceway

Sonoma, California

July 4-6

NHRA Division 7 Race

Infineon Raceway

Sonoma, California

August 6-10

Indiana State Fair

Indianapolis, Indiana

For entrance and admission details, log onto:
www.infineonraceway.com www.indianastatefair.com

SMART GARAGE RESOURCE DIRECTORY

GRAB LIFE BY THE HORNS



DODGE

dodge.com
 800-4A DODGE


IT'S TIME TO RETHINK THE GARAGE™

GladiatorGW.com
 866-342-4089

sharpusa.com
 800-BE SHARP

- Actiontec Electronics
actiontec.com
 888-436-0657
- Humanscale
humanscale.com
 800-400-0625
- Lutron
lutron.com
 888-LUTRON1
- Stoner
stonersolutions.com
 800-227-5538
- Armor All
armorall.com
 800-222-7784
- Homelite
homelite.com
 800-242-4672
- Perception Kayak
kayaker.com
 800-59-59AYAK
- STP
stp.com
 1-888-GO-4-STP1
- Coleman
coleman.com
 800-835-3278
- John Deere
deere.com
 800-537-8233
- Progress Lighting
progresslighting.com
 864-599-6000
- TaylorMade
Tmag.com
 800-888-2582
- Czarnowski
czarnowski.com
 800-247-4302
- Kohler
kohler.com
 800-4 KOHLER
- Rechargeable Battery
 Recycling Corporation
rbrc.com
 800-8-BATTERY
- TLC/Junkyard Mega-Wars
discovery.com
 click on TLC
- DCS Grill
dcsappliances.com
 800-433-8466
- LapVantage
 The Plastic Smith
lapvantage.com
 800-394-3774
- Research Frontiers
smartglass.com
 888-SPD-REFR
- Vector
vectormfg.com
 866-584-5504
- Georgia-Pacific
gp.com
 404-652-4000
- Leatherman
leatherman.com
 800-847-8665
- Rust-Oleum
rustoleum.com
 800-323-3584
- Wilsonart
wilsonart.com
 800-710-8846
- Giant Bicycles
giant-bicycles.com
 800-US-GIANT
- Lennox Industries
davelelenox.com
 800-9-LENNOX
- Ryobi
ryobitools.com
 800-525-2579

Adventure

POPULAR SCIENCE

"MY FIRST CONCERN WAS WHETHER WE WOULD SURVIVE THE ICE CREAM. I HAD VISIONS OF FROSTBITE OF THE THROAT." PAGE 92



One Dive, One Breath

Free dive to 55 feet? No sweat.

It's the return trip that could kill you. By Logan Ward

FIRST PERSON



BOTTOM'S UP The writer free dives on a 45-foot shipwreck off Grand Cayman Island.

MY HEART BEGINS POUNDING the theme from *Jaws*, triple tempo, as the shipwreck inches into view. Given the task I face—kicking down 55 feet on a single breath—such anxiety is a perfectly normal response, although precisely the wrong one for a free diver. Fear releases adrenaline, which jacks up the heart rate, constricts blood vessels, and causes rapid, shallow breathing. But if I can relax, an entirely different experience awaits: The exhilaration of probing the deep blue unencumbered by air tanks.

That's the essence of free diving, a sport defined by lung capacity and physical endurance. Taken broadly, "free diving" encompasses everything from floating face down in a swimming pool (static apnea) to plunging more than 500 feet on a weighted sled (no-limits diving). But the majority of the



SWIM TOWARD THE LIGHT A free diver ends the most perilous phase of his dive: ascent.

world's 20,000 free divers fall into the "constant ballast" category, relying on little more than a mask and fins to dive as far as their lungs will take them. That's where I fit in. I've come to Grand Cayman Island to put my apnea limits to the test, and to use the two-day Advanced Free Diver course at Divetech to hone my family-vacation snorkeling skills into spear-fisherman shape.

Free diving dates back to at least 4,500 B.C. and Mediterranean mother-of-pearl divers. But it wasn't until Paul Bert, the 19th-century French physiologist, first described the physiological "dive reflex" in marine mammals that scientists began speculating on its existence in humans. They soon discovered that nerve receptors in the face tell the heart to throttle down the instant we hit water, causing pulse rates to drop as much as 50 percent in novice divers and sink to eight beats per minute in world champions. Blood vessels in the skin and extremities constrict, while those in the brain, heart and lungs dilate, shunting blood to the places that count. Even the spleen gets in on the act, releasing an extra dose of red blood cells to ferry oxygen around the body.

"Just sitting in a pool moves a liter of blood from the body's periphery into the chest," says Claes Lundgren, professor of physiology and biophysics at the State University of New York at Buffalo, and a top free-diving researcher.

Until the mid-20th century, scientists believed that the chest cavity would implode at around 115 feet. Water pres-

ADAPTING TO DEPTH

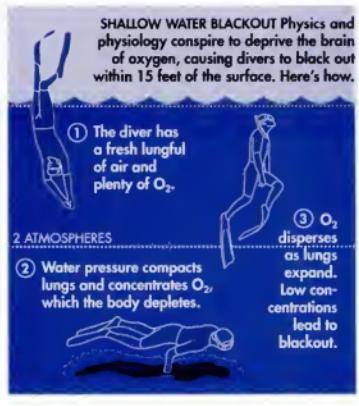
When it comes to swimming underwater, the human "dive reflex" isn't so different from that of sea elephants and other marine mammals. Here's a look at the physiology that keeps us kicking.



sure, they argued, reaches 65 pounds per square inch at that depth, which is enough to shrink lungs to the size of grapefruits and collapse rib cages like empty soda cans. Their theory went out the window in the 1950's and early 1960's, however, when divers like Enzo Maiorca returned from beyond 115-feet with rib cages intact. We now know that water pressure forces blood vessels in the chest to swell, filling the void left by the lungs with an incompressible fluid.

That's all well and good, but before testing this body's dive reflex, it seemed prudent to spend some time in the Divetech classroom. Step one: Learn how to breathe. Emulating a human bellows, I filled the lower two-thirds of my lungs with a deep belly breath, and then inflated my chest by stretching my intercostal

SHALLOW WATER BLACKOUT Physics and physiology conspire to deprive the brain of oxygen, causing divers to black out within 15 feet of the surface. Here's how.



in the Divetech classroom. Step one: Learn how to breathe. Emulating a human bellows, I filled the lower two-thirds of my lungs with a deep belly breath, and then inflated my chest by stretching my intercostal



BREATHLESS Cali Johnston and fellow Cayman Free Diving Club members gather in the Cobalt Coast Resort pool for static apnea training. The current breath-hold world record: 8 min. 6 sec.

(between rib) and subclavian (below collarbone) muscles. This produced a burning sensation—caused by expanding tissue—and an oxygen-rich wooziness. "You might be sore tomorrow," warned Cali Johnston, my instructor. "When I first learned breathing cycles, it felt like someone punched me in the ribs."

Out at the wreck, a 45-foot freighter called the *Doc Poulson*, this breathing technique pays off as I begin my "breathe up"—the pre-dive cycle encompassing a minute of normal respiration, 10 to 20 slow, deep breaths, and several faster "super vents." I've already aced the various drills, such as underwater mask clearing and a mock deep-water rescue. Now it's go time. To pass the class, I must dive to the bottom and retrieve a handful of sand—about a minute and a half round-trip.

Among the dangers of free diving, the most disconcerting is shallow-water blackout—the brain's frightening tendency to shut down within 15 feet of the surface during the ascent. As you descend, water pressure squeezes your lungs, condensing the oxygen and giving you what feels like a second breath. During the return trip, however, your lungs re-expand, dissipating what's left of your oxygen. If levels drop too low, not enough will move into the bloodstream, and the lights go out. Fortunately, the body's laryngospasm reflex kicks in to tighten the throat and keep water out for up to a minute—just enough time for your dive buddy to drag you to the surface, tilt your head back, and beg, "Breathe, baby."

Knowing Johnston will be there watching my eyes as I ascend (seeing them roll back in the head is a red flag), I dip below the surface. Staying in the syringe—dive spear for a tight hydrodynamic column—I kick down to 30 feet, my point of neutral buoyancy, and then sink effortlessly to the bottom. I feel good—surprisingly good—thanks to the densely packed oxygen molecules in my lungs.

Lingering a moment, I peer up at the mirrored surface that separates this liquid world from mine. Diving to 55 feet was no sweat. I figure I could dive twice that with a little practice, reaching what scientists thought, not 50 years ago, was the body's depth limit. Today, however, that boundary has been pushed to at least 531 feet (the current no-limits world record), which begs the question: Just how deep can humans go? "We don't know that yet," says Lundgren, adding ominously. "But one day someone will find out." ■

.HOW TO

DIVE LIKE A PRO

Cali Johnston, my instructor at Divetech, began free diving on a bet seven years ago. Now she can hold her breath for five minutes and dive up to 150 feet—skills that helped her push the Canadian women's free-diving team to win top honors at the 2001 World Free Diving Championships. Here are her tips for diving deep without sucking seawater.

- **BREATHE RIGHT.** Cali suggests a breathe-up cycle of at least three minutes between dives to overcome oxygen debt. Combine deep belly breaths with full upper-chest breaths. Never hyperventilate. That blows off excess CO₂—your body's stimulus to breathe.



- **RELAX.** Stress increases heart rate, constricts the wrong blood vessels, and leads to panic. Stay calm with measured breathing.

- **STAY IN THE SYRINGE.** Keep your body streamlined to

cut down on water drag, using hip and knee joints to flutter kick.

- **LISTEN TO YOUR BODY.** When you need to breathe, you might feel a burning sensation in the back of your throat and contractions in your diaphragm. "When I feel a couple of contractions," says Cali, "I know it's time to surface."

- **NEVER DIVE ALONE.** This is the sport's cardinal rule. "I don't care if you're practicing at home in the toilet," she warns. "If you black out, you'll drown."

.ADVENTURE GUIDE

Divetech, Cobalt Coast Resort, Grand Cayman Island • This full-service dive school offers a range of free-diving courses, from a \$200 one-day beginner's class that will take you to 30 feet to a tailor-made no-limits sled course for competitive divers. www.divetech.com

International Association for the Development of Apnea • The AIDA was established in 1992 to govern the world of free diving, and has since grown to include chapters in 29 countries. Its Web site is a one-stop shop for courses, records and upcoming competitions. www.aida-international.org—L.W.

NO TANKS Free of scuba gear, a diver glides silently underwater.



Microcrystalline In 30 Seconds

Behold the smooth,
sweet powers of liquid N.

GRAY MATTER



LIQUID NITROGEN IS cold. Very cold. So cold that if a drop falls on your hand, it feels like fire. So cold that it can turn a fresh flower into a thousand shards of broken glass. So cold that it can make half a gallon of ice cream in 30 seconds flat.

I first heard about liquid nitrogen ice cream from my friend Tryggi, an Icelandic chemist working in the Midwest (these things happen). He suggested we make it for dessert at a dinner party I was planning. Yes, he said, he had a recipe, something he'd seen in *Chemical and Engineering News*.

Now, right off the bat you have to worry about a recipe found in *Chemical and Engineering News*, the principal trade publication for the sort of people who build oil refineries, shampoo factories and large-scale plants for the fractional distillation of liquefied air (which is where liquid nitrogen comes from). But for the party I was planning, it was perfect: The well-known author Oliver Sacks was coming to visit with my collection of chemical elements; I needed some after-dinner entertainment.

My first concern was whether we would survive the ice cream. That and, if it didn't kill the cook, whether it would be any good. I had visions of hard, crusty stuff that caused frostbite of the throat. It turned out nothing could be further from the truth.

We mixed up a standard ice cream recipe calling for



LIKE ICE CREAM FROM TRITON

[1] Besides the liquid nitrogen, no special ingredients were used in this experiment. [2] The non-cryogenic ingredients were combined in a mixing bowl. [3] The nitrogen was added a cup at a time. Note the use of heavy cryo gloves—this was not an occasion for oven mitts. [4] The concoction was stirred thoroughly and continuously to keep an unbreakable crust from forming. [5] The ice cream was ready to eat when smooth and free of lumps.

two quarts of cream, sugar, eggs, vanilla and flavoring. (Just about any ice cream recipe and flavor will work.) Then, working in a well-ventilated area (lest the nitrogen displace oxygen from the air) and with due regard for the ability of liquid nitrogen to freeze body parts solid, we gently folded about two liters of nitrogen syrup directly into the cream, much as you would fold in egg whites.

The result, literally 30 seconds later, was a half-gallon of the best ice cream I'd ever tasted. The secret is in the rapid freezing. When cream is frozen by liquid nitrogen at -196°C , the ice crystals that give bad ice cream its grainy texture have no chance to form. Instead you get microcrystalline ice cream that is supremely smooth, creamy and light in texture. Martha Stewart, eat your heart out.

The kids were amused by the clouds of water vapor, though being kids they didn't find anything out of the ordinary in the procedure. They probably think everyone makes ice cream this way. Boy, will they be in for a shock the first time they see it done the old-fashioned way at camp: You want me to do *what* for a half hour?

A word of caution: Liquid nitrogen can be dangerous in careless hands. Tryggi and I are both trained chemists, and he actually knows what he's doing. Don't try anything like this unless you do too.—THEODORE GRAY



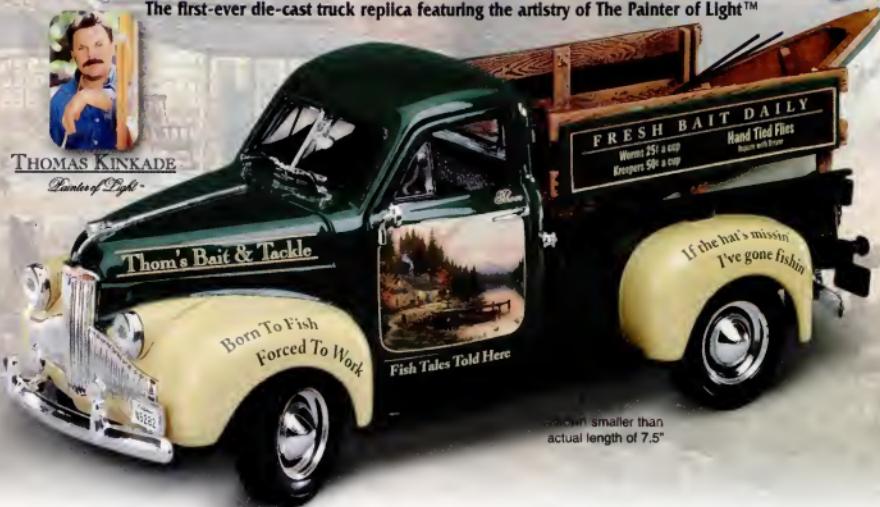
ELEMENT MAN
Theodore Gray is a co-founder of Wolfram Research, Inc., maker of the software program *Mathematica*. In his spare time he plays with elements at www.periodictable.com.

THOMAS KINKADE "The End of a Perfect Day"

The first-ever die-cast truck replica featuring the artistry of The Painter of Light™



THOMAS KINKADE
Painter of Light



In the heart of everyone who loves the outdoors, there's a perfect place: a peaceful haven where the water is crystal clear and the fish are always biting. Renowned Painter of Light™ Thomas Kinkade captured this idyllic vision in one of his best-loved works, "The End of a Perfect Day". Now for the first time ever, the artistry of Thomas Kinkade is featured on this unique die-cast replica.



"The End of a Perfect Day" pickup truck is the first issue in the *Rustic Retreats* collection that captures the glory of the great outdoors in rugged

die-cast metal. Hand-crafted by Ertl® in 1:25 scale, "The End of a Perfect Day" features a full-color reproduction of Kinkade's masterwork on the cab doors, along with humorous fishing slogans and "Bait & Tackle" signs on the fenders and hood. This authentic replica of a classic 1947 Studebaker is complete with rubber tires, a chrome-finished grille and hubcaps, a fully detailed interior — plus a rowboat full of fishing gear that can be loaded and unloaded separately. A certificate of authenticity and collector's booklet assures the authenticity of your Hamilton Authenticated purchase.

Reserve your pickup today!



Please Respond Promptly

YES! Please send me "The End of a Perfect Day" 1947 Studebaker replica. I need **SEND NO MONEY NOW**. I will pay for my truck in two monthly installments of \$29.95 each, the first to be billed just prior to shipment.

My satisfaction is completely guaranteed. I may return my replica for any reason within 365 days.

* Plus \$6.95 for shipping & handling. Illinois residents add state sales tax. Please allow 4-6 weeks for shipment.

collectiblestoday.com

©Thomas Kinkade, Media Arts Group, Inc., Morgan Hill, CA
©2002 Hamilton Authenticated

Exclusive edition only available from

H Hamilton Authenticated
9202 Center for the Arts Drive • Niles, IL 60714

Name _____

Address _____

City/State _____

Zip _____ Telephone _____

97981-CC2R3

97981-E16001



You recycle your old motor oil and your old paint. How about your used rechargeable batteries?



You know all those rechargeable batteries you have laying around that won't hold a charge anymore? Don't throw them away. Recycle them. Visit www.rsrc.org or call 1-800-B-BATTERY to find the drop-off center nearest you.

RBRC is an official sponsor of the *Popular Science* Smart Garage. RBRC spokesperson, Richard Kam, "AI" from *Home Improvement*, will appear at the NASCAR Race on Sunday, June 22 at Infineon Raceway in Sonoma, CA.



DEMOLITION MAN

Chuck Cramer, consumer watchdog, on a break in UL's North Carolina testing facility.

ODD JOBS



He Blows Things Up So You Don't Have To

NAME Chuck Cramer **AGE** 50

JOB During his 19 years as a laboratory technician for Underwriters Laboratories, Cramer has set coffee makers on fire, knocked computers off desks, short-circuited fans, and blown up everything from toasters to curling irons—all in the name of consumer safety.

WORKPLACE UL's testing facility in Research Triangle Park, North Carolina. A typical day might find Cramer conducting an endurance test on a chainsaw in the Noisy Room, freezing a light fixture to gauge cold-weather performance in the Fixture and Ballast Room, or smashing television screens in the Thrown Projectiles Room to see how far the glass flies.

CURRENT PROJECT From behind a Plexiglas window, Cramer rolls metal ball bearings into an air cannon, which fires them directly into the bag of a lawnmower. If they tear through the bag, so too might rocks and debris. The bag holds strong: America's shins are safe.

CRITICAL TOOL He has several. Two of note are a 1.18-pound suspended steel ball in the Thrown Projectiles Room, which mimics a 22-mph fastball (effectively, the maximum destructive force of kids playing catch), and a power analyzer in the High Voltage Room, which can gouge, for example, whether a blow-dryer rated at 1,500 watts actually sucks down 1,800 (the difference between a good hair day and a blown circuit).

GREATEST CHALLENGE With dozens of rooms recreating hundreds of worst-case scenarios, it's tough to keep track of every safety protocol. And even if you do, mishaps still happen. A few years ago Cramer sparked a fire by running an electrical current through what turned out to be a faulty power strip. He has been known as "Fire Truck Chuck" ever since.

FINAL WORD "Sometimes we'll brew a hundred pots of coffee and everything will look normal. Other times four will burn up because we shorted out their thermal protectors. We're a watchdog for the people, trying to protect them from themselves." —CARRIE LORANGER GASKA

To shatter products yourself, visit UL's Test the Limits Lab at Walt Disney World's Innovations at Epcot. www.ul.com/testthelimitslab

Yes! If your mattress is full of springs, water, or air, you may need to fix it—with a brand new Tempur-Pedic.

NASA recognizes it. The media praise it. More than 25,000 medical professionals worldwide strongly recommend our new Weightless Sleep™ technology to their patients.

This *otherworldly* miracle has to be *felt* to be believed.

The thick, ornate pads that cover most mattresses are necessary to keep the hard steel springs inside. But they create a hammock effect outside—and can actually cause pressure points. Inside Tempur-Pedic beds, billions of microporous memory cells function as molecular springs that contour precisely to your every curve and angle. The result... luxurious WEIGHTLESS COMFORT. Tempur-Pedic scientists used NASA's

Is there

a problem inside your mattress you ought to fix?

anti-G-force research to invent TEMPUR® pressure-relieving material—a remarkable new kind of viscoelastic bedding that reacts to body mass and temperature. It literally "molds" itself to your exact shape and weight.

Which is why millions of Americans are falling in love with the first *really* new bed in 75 years: Tempur-Pedic's Swedish Sleep System®

Our mattress never requires turning, rotating, or flipping. Unlike any other mattress, the Tempur-Pedic bed transmit virtually no body motion between sleep partners.

Our Weightless Comfort miracle bed is available nowhere else. It makes all other beds obsolete!

Please call now, without any obligation, for a FREE DEMONSTRATION KIT.



THE ONLY MATTRESS
RECOGNIZED BY NASA
AND CERTIFIED BY THE
SPACE FOUNDATION®



Furniture
components
not included



TEMPUR-PEDIC®
PRESSURE RELIEVING
SWEDISH MATTRESSES AND PILLOWS

1713 Jaggar Fox Way, Lexington, KY 40511



Tempur-Pedic
Swedish Mattress.
"This is the
mattress that set
the industry abuzz!"
—Consumers Digest 2003



YOURS FOR
THE ASKING!



For free demo kit,
call toll-free

1-888-359-8469

or fax 1-866-795-9367

FYI

FACTS,
ANSWERS,
ODDITIES &
ENTERTAINMENTS
FOR A MONTH
OF SCIENCE



FANTASTIC PHYSICS

SUPERHERO STRONGMAN SHOWDOWN: TERMINATOR VERSUS THE HULK

Two of this summer's biggest special-effects extravaganzas will go head-to-head at the box office this month—*T3: Rise of the Machines* will be released on July 2, shortly after *The Hulk* hits theaters on June 20. In a just world, the movies would be judged not by gross receipts but by the strength of their characters. Literally. And so we ask: In a toe-to-toe matchup between the two most physically powerful sci-fi characters to hit the screen since Superman,

who will emerge as the strongest? Let physics be the judge.

The Terminator, cyborg from the future, killing machine sent back through time, takes bullets in the chest without flinching, tosses bodies around as if they were rag dolls. Strong, yes, but compared with the pantheon of superheroes, what feats can he perform that set him apart? Never in the three movies does he demonstrate truly godlike strength; only the occasional fist through a wall and bullet through the back. His strength rises from tenacity, the robotic single-mindedness that is his existential birthright. His physical

power—occasional broken walls aside—is merely human-plus.

Compare this with the Hulk—mild-mannered Bruce Banner transformed by rage and gamma rays into a 15-foot-tall muscled madman. In one scene from the upcoming movie, he grabs a tank by the turret, twirls and throws it far into the distance. Let's pause to consider this for a moment. He'd need to get that 60-ton tank moving about 170 mph to throw it 2,000 feet. Doing that in two seconds requires 100,000 hp, or the strength of a naval destroyer packed into a superhero's body.

Although not as logical or tenacious as the Terminator—helpful qualities when you're built to kill—the Hulk compensates for his deficiencies with pure muscle power. We salute you, Hulk, and bestow upon you our inaugural superhero strongman award. Can't wait for the sequel.—MICHAEL MOYER

INTERSTELLAR INVADERS

DID SARS START IN SPACE?

As SARS evolved from what seemed like a small problem into a global scare, everyone assumed that the virus's spread was abetted by air travel: someone returning from China, for example, carrying SARS to Canada. Few, though, considered the possibility that the vehicle the virus traveled in might have been a comet. Yet to one man, space travel is the best explanation for the disease's spread.

Chandra Wickramasinghe, the Cardiff University astronomer who first proposed this possibility, says the idea makes sense when one considers the SARS track. The comet carrying the virus would begin to break up over the Himalayas, the thickest section of the atmosphere at that altitude. It would first deposit its microbial contents over China, and then gradually sprinkle what remained over the rest of the world. What appeared to be transmission by globe-trotting tourists would actually be the gradual deposition of microbes by an interstellar space rock. Wickramasinghe says the comet theory could also explain the influenza pandemic of 1918. Once again,

WIN A POPSCI T-SHIRT!

Fact: If your FYI question is published, we'll send you a PopSci T-shirt. Write to fyi@popsci.com



We found our best watch in a history book

In 1923, a small watchmaker in Switzerland designed the first watch to display day, month, date, AM and PM. It is rumored that only 100 of these magnificent timepieces were made and this mechanical marvel was almost lost to history. Today, early chronographs from the 1920's designed in the Schaffhausen region are so rare that one original watch can fetch more than \$300,000 at auction.

These watches were among the most stylish and complex of the roaring 20's. And yet no one has attempted to recreate the designs of these early chronographs until now. The watch design that you see here has been painstakingly created from designs in Watch history books printed in the 1920's. The watch even has a rotating AM/PM dial that graphically depicts the sun and the stars. The owner of this classic chronograph watch is sure to look

distinguished since every detail from the sweeping second hand to the genuine leather strap has been carefully engineered. This reissue is a limited edition that comes with a certificate of authenticity so that you will be able to own a collectors watch far rarer than watches costing thousands more.

This watch has a classic mechanical movement with automatic power inspired by the engineering breakthrough of John Harwood in 1923, thus the watch never needs batteries and never needs to be manually wound. The watch comes in a beautiful mahogany toned wood case.

This is a chance to claim a piece of watchmaking history in an elegant design that is still priced to wear everyday. This offer is being made directly to you so you can add this watch to your collection at a very affordable price.

The watch comes with a 30 day no questions asked money-back guarantee. If you're not completely satisfied, simply return it for a full refund of the purchase price.

Not Available in Stores
Call now to take advantage of this limited offer.

1923 Timepiece ~~\$299~~ \$199 + S&H.

800-859-1602

Promotional Code STR121

Please mention this when you call.

To order by mail, please call for details.

NEXTTEN 

products for your next ten years.

14101 Southcross Drive W.
Dept. STR121
Burnsville, Minnesota 55337

For fastest service, call toll-free 24 hours a day **800-859-1602**



FYI

that outbreak arose first in China, then in distant parts of the world—before air travel existed.

In expanded form, this outlandish idea doesn't only account for the origin of SARS, but for all life on Earth. British astronomer Fred Hoyle first in-

troduced the theory, known as panspermia, more than 20 years ago. Hoyle and his collaborator Wickramasinghe took issue with the notion that life spontaneously arose from a primordial soup, insisting instead that microbes seeded Earth from space. (You may be wondering where those space microbes came from. So are we.)

Although the evidence remains tenuous, the geological record provides some backing for panspermia. The earliest signs of microbial life, from roughly 4 billion years ago, coincide

with a period of high cometary impacts. Adherents continue to search for additional proof. Wickramasinghe's group has used high-altitude balloons to collect microorganisms from 41 kilometers above Earth. They found many more than expected, suggesting, says Wickramasinghe, that the material fell from above instead of upwelling from the lower atmosphere. But the real tests, still pending, will be the measurements of carbon isotope ratios in the microorganisms. "If they turn out to be different from Earth [organisms]," he says, "then the game is up." —GREGORY MONE

WEB SCIENCE

ALL THE SCIENCE NEWS THAT'S FIT TO PRINT (AND SOME THAT'S NOT)

In the beginning, there was Slashdot, one of a handful of web logs, or blogs, on the Net. Six years later, more than 500,000 blogs have emerged. These message-board-like Web sites are timestamped compilations of news stories and personal commentary about, well, anything that interests the blogger. When we asked Cameron Marlow, who tracks blog growth for MIT Media Lab's blogdex, how many are science and tech related, he responded philosophically: "To ask how many of them touch on science and technology is to ask how many people are interested in science and technology—my guess is most of them, in some form or another." That being the case, there are hundreds of thousands of science blogs out there, most of them watered-down pretenders obscuring the few gems. We've cleared away the chaff to present the five best science blogs in the known universe.—JENNY EVERETT

Slashdot.org/science
Call it a guilty pleasure. You're not necessarily attracted to it, but you can't resist its charm. Constantly updated with info from dark corners of the Web you wouldn't otherwise visit, Slashdot is still the most recognized and informed science-related blog on the Net. Intelligent musings ramble from general science to space to biotech. *Recommended dose: twice a day.*

Scienceblog.com

Jam-packed with 16 categories and minimal annoying commentary, this

DIGITAL HEIGHT CONTROL™

PlasmaCAM's™ popular CNC machine comes standard with state-of-the-art Digital Height Control™

See the worlds best selling plasma cutting machine on video, \$9.95 (postage paid).

New 24 page full-color catalog shows some really neat things cut on this machine and the information you need to own one. Optional art packages are available on disks in PlasmaCAM™ format-ready to run. Call today and order your FREE catalog and see what you've been missing.

PlasmaCAM™ machines are being used by many individuals, businesses and schools and are even in use on board US Navy ships.

PO Box 19818
4932 Graneros Rd. Unit B
Colorado City, CO 81019
(719) 676-2700
fax (719) 676-2710
www.plasmacam.com

PlasmaCAM Inc.

SunTamer Hat™

The amazing Sun Tamer Hat's features include:

- Repels heat, instead of absorbing it
- Innovative air-circulation ring prevents heat entrapment
- Stylish design shades the entire head and neck
- Keeps glasses dry – even in pouring rain
- Wind tested to 50 mph
- Dark green under brim
- Adjustable, washable and removable elastic headband
- Decorative leather hatband



A cool idea for everyone!

call 1-800-421-2586 or visit www.suntamerhat.com

And in the construction world... our Pro-Trim is bendable to cap wood on homes - plain or grain

- Any brake will bend and cut Pro-Trim.
- Our patented Brake Upgrade System will cut your work time in half.
- Pro-Trim is also an excellent replacement for canvas boat tops because it repels heat and is so durable. It comes with a 10 year warranty and is 100% UV rated.



On Shore or Offshore... you'll love our products for sure!!!

Our Scaffolding System is OSHA
Recognized to 50'.



©2001 Alum-A-Pole Corporation Scranton, PA. Patents issued and others pending.

CALL 1-800-421-2586

Or visit: www.alumapole.com | www.pro-trim.com | www.suntamerhat.com

site gets about 5 to 10 posts daily. Access day-old articles on the right side of the page. *Recommended dose: once every two days.*

Impactlab.com

Hosted by the DaVinci Institute, a futurist think tank known for uncovering emerging technologies, the site, with its 91 topics, provides a good balance of the expected (news from CNN, New Scientist, BBC, space.com) and the unexpected (tidbits from little-known sites like betterhumans.com). *Recommended dose: once a day.*

Techdirt.com

This site tends to be more tech than science and more Wall Street than basement nerd. Categories like News You Can Do Without and (Mis) Uses of Technology come off as snarky but smart. Check out Up-To-Date, a

sometimes-weekly summary of the high-tech world. *Recommended dose: twice a week, Monday and Friday.*

Mygeekdom.com

Like Slashdot with a potty mouth. You'll laugh, you'll cry, you'll become slightly smarter, or dumber. Depends on the day. *Recommended dose: once a week, when the kids aren't around.*



BOOK OF THE MONTH

BEHIND THE SCENES WITH THE LITTLE SCOOTER THAT COULD

When the Segway Human Transporter (a.k.a. Ginger) was unveiled in November 2001, ending months of speculation about the secretive project, some people were disappointed. They expected a teleportation device or a time machine. But as anyone lucky enough to ride the self-balancing Segway soon swore, the \$5,000 machine was amazing on its own terms. The press anointed inventor Dean Kamen, whose

specialty had been medical tech (including a type of stent that currently props up one of Dick Cheney's valves) as a modern-day wizard, as if Kamen had whipped up Ginger in his garage.

In *Code Name Ginger*, a behind-locked-doors look at Segway, Kamen and his huge cast of engineers, executives and investors, writer Steve Kemper shows that Ginger's creation was anything but magical. The engineers, naturally, turn out to be the real heroes. Kemper is at his best when he pulls us into their world, exploring their creativity as they build, tweak, and rebuild the prototypes. Even the financial story, which consumes much of the book's second half, entertains. Will Ginger change transportation and invent a new world, fulfilling its own hype? Kemper leaves that for the reader, and the markets, to decide.—GREGORY MONE

THE POPSCI READING LIST

For our monthly column on the best science books, as well as notable author Q&As and more, check out: www.popsci.com/books

WeatherTech®

Automotive Accessories

CLASSIC™

Premium Rubber Mats



Available in
Black, Tan
or Grey



Pet Barrier

Visit us at
mats.com

WeatherFlectors™



WeatherFlectors™ applications to fit over 600 vehicle models!

Cargo Liners



Applications for
virtually any vehicle!

ADVANTAGE™

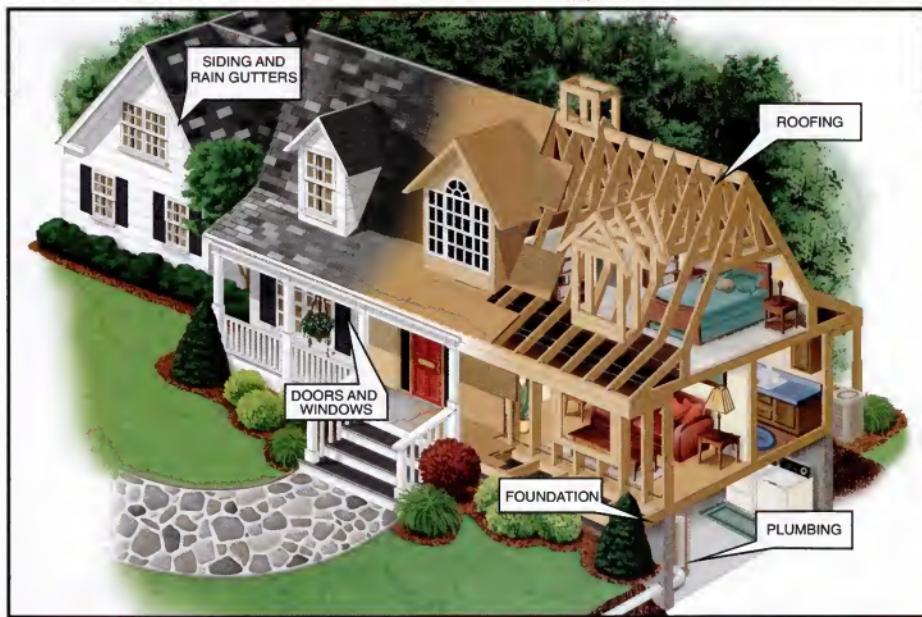
Luxury Carpet Mats

Cargo Liner applications to fit over 900 vehicle models!

MacNeil.

800 441-6287

EARN up to \$56,000 a year as a Home Inspector!*



Enjoy Your Work!

Every day as a Home Inspector will be different. You'll inspect homes all over town, meet new clients, and work with your head and your hands! It's a great full-time career or a great way to earn extra cash on weekends.

Home Inspectors Are in Demand!

Thousands of homes are sold every day. Home inspectors help potential buyers make sure they're getting the kind of house they're paying for and earn good money for their appraisals.

Consumers, banks, and mortgage companies hire home inspectors to check out houses. Plus, skilled home inspectors can earn up to \$56,000 a year.*

Training that's Convenient!

Learning materials are sent right to your home! There are no classes to attend — you study when it's convenient for you and set your own schedule.

Mail coupon, or for faster service, call toll free

1-800-572-1685 ext. 3719

Call anytime, 24 hours a day, 7 days a week.

Or visit our website:

www.EduDirect-usa.com

Online enter ID# APCS73S

THOMSON
EDUCATION DIRECT

YES! Please send me free information on your Home Inspector Program — or one of these other great at-home training programs! **Please choose ONE only.** No obligation.

Building Trades

- 15 Home Inspector
- 06 Electrician
- 104 Carpenter
- 145 Residential Remodeling & Repair
- 146 HVAC Technicians
- 31 Professional Locksmithing
- 384 Furniture & Cabinet Maker
- 151 Plumber
- 102 Professional Landscaper

Mail coupon to:

Dept. APCS73S
925 Oak Street
Scranton, PA 18515-0700

Career Diploma Programs

- 27 PC Repair
- 70 Small Business Management
- 25 Gunsmith
- 54 AutoCAD®
- 83 Web Page Designer
- 33 Motorcycle Repair Technician
- 158 Auto Body Repair Technician
- 48 Police Investigator
- 85 Drafting
- 55 Diesel Mechanics
- 89 Small Engine Repair

Diploma Programs

- 04 Auto Repair Technician
- 390 Bookkeeping
- 100 Business Assistant
- 56 Pet Groomer
- 395 Dog Obedience Trainer/Instructor
- Diploma
- High School Associate in Specialized Business Degree Programs
- 60 Business Management
- 61 Accounting

PLEASE PRINT

Name _____ Age _____

Street _____ Apt. # _____

City/State _____ Zip _____

Phone () _____ E-mail _____

The Toughest Glue On Planet Earth

Gorilla Brand Premium Glue is the all purpose, interior/exterior glue ideal for most repair and bonding needs. It's great for indoor/outdoor furniture repair, woodworking projects, as well as general repairs around the house. Bonds wood, stone, metal, ceramic and more! Incredibly strong and 100% waterproof.



for retailers near you:
www.gorillaglue.com

I-800-966-3458

[CONTINUED FROM PAGE 78]

a two-stage light-gas piston gun at HITF accelerates plastics and metals in various shapes and sizes (up to an inch in diameter) to 16,000 mph, then smashes them into mock-ups of, for example, the outer skin of a space-craft. Every exposed part is vulnerable, says Dave Baker, HITF project manager, whether it be "a new particle-impact shield, or a cable, or a tether or anything like that." NASA has many gas-gun facilities around the country but likes an isolated building at White Sands best. "We can shoot hazardous targets here," says Baker. "Propellant tanks or oxygen tanks, which might explode, or beryllium, which could be toxic." Every test is filmed with a Cordin rotating-mirror camera. The footage and other data are analyzed by scientists at Johnson Space Center. Baker was mum on whether the recent space shuttle disaster investigation involved HITF work, though it almost assuredly did: Space debris was one of the possible causes linked to the demise of Columbia.

STOPPING LIGHT COLD

The cameras that for the past six years have made up Cordin's fastest group don't have moving parts at all—or film, for that matter. These cameras shoot at rates of up to 200 million frames per second, a rate useful, Nathan Nebeker says, for "things like the moment of combustion of aerosolized jet fuel: You're trying to get an even wave front so that you have a controlled burn."

In the so-called gated, intensified CCD cameras, light from the objective lens passes through a beam splitter, and multiple, identical images are formed on the photo cathodes of microchannel plate (MCP) image intensifier tubes, similar to those used in night vision goggles. Striking the front side of the intensifier, the photons free electrons inside each tube; the electrons cascade through the tube, freeing more as they proceed, until they strike a phosphorescent surface back, which converts the electrons back into a light pattern. "The intensifier does two things," explains Sid Nebeker. "It magnifies the light several thousand times, and it switches the light very,

very fast—in a matter of nanoseconds. When you have such a short exposure you need that high light gain to get useful images."

The images from the MCPs pass through bundles of glass fibers, stretched long and thin at one end to shrink down the picture. The small ends sit against 1-megapixel charge-coupled devices—pretty much what you'd find in a digital consumer camera—which record the images.

POPULAR SCIENCE asked Nathan Nebeker if he could set up a demonstration that would make nanosecond durations comprehensible in visual and intuitive terms. Why not, he suggested, shoot a series of photos of light as it travels in real time across a very short space—say, 100 feet? The fastest thing in the universe stopped dead as it makes its way across an ordinary room.

It is the first time Nebeker has attempted this, though not the first time it has been done—a single photo of light "stopped" by a different technology in the late 1940s was termed "one of the most important photographs of the century" in this magazine (for details, see www.popsci.com/exclusive). It's essentially a gee-whiz shot, Nebeker admits, but not without its challenges. Light travels about a foot per nanosecond, so a 7-nanosecond laser pulse, if you were able to see it, would look like a discrete packet of photons 7 feet long.

Nebeker sets up shop one afternoon at the labs of Spectra-Physics in Mountain View, California, where he can use a laser capable of generating 7-nanosecond pulses of brilliant green laser light. The camera he brought shoots only two frames; Nebeker wants a pair of sequential pictures—an ultrashort movie, essentially—that will mark the progress of the light over a short period of time.

The laser light will travel through a series of spaces as it bounces through angled mirrors that face each other in pairs along a 9-foot-long table. A 7-foot-long pulse of light will travel through the mirror course in 90 nanoseconds.

With a camera capable of shooting 10-nanosecond frames, the trick is figuring out which 10 nanoseconds to capture, there being 90 million such periods in one second alone. There is

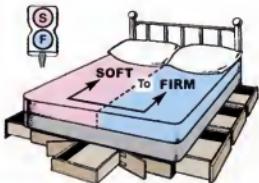


Gorgeous still and animated sequences of Cordin high-speed photography can be seen at www.cordin.com/images.html

PS WEB CONNECTION

www.popsci.com/shop

To advertise call Kathryn Alimo at 203-267-4251 or email kathryn@mi-ms.com



ANDERSON ULTIMATE BED

Save space with a solid wood underbed dresser, side tables, lighted headboard. Sleep better with an adjustable mattress featuring dual controls, visco-elastic foam, wool filled, antibacterial, launderable mattress top. All items can be purchased separately. 30-day home trial. Catalog #813 1-800-782-4825.

www.ultimatebed.com



ARCHITECTURAL PRODUCTS BY OUTWATER

Where the Pros Shop. We feature 40,000+ Decorative Building Products at the Lowest Prices! - Architectural Moldings & Millwork, Columns, Wood Carvings, Wrought Iron Components, Lighting, Ceiling Tiles, Hardware, Furniture & Cabinet Components, Wall Coverings, Fireplace Surrounds and more! Shop Online! FREE Catalog!

www.Archpro.com



BCS AMERICA LLC

The new BCS Electric Mini-Cultivator weighs only 10.6 lbs...1/2 the weight of mini-tillers. It's fun and easy to weed gardens, renew mulch, and mix soil amendments. \$179.99. For literature or to order, call 1-800-227-8791.

www.bcs-america.com



BUG BAFFLER, INC.

Insect Protective Clothing for all outdoor activities. Concerned about bug bites and the diseases they cause? Keep bugs from biting. Like wearing your own greenhouse. Don't let the bugs keep you indoors. Free Brochure. Dealer requests invited: email: sales@bugbaffler.com. 1-800-662-8411.

www.bugbaffler.com



BRIGGER DESIGNS FOR COMFORT

Available in many sizes and postures, Brigger chairs, rockers, recliners and sofas will make anyone comfortable. Their beautiful solid wood construction, elegant lines and quality craftsmanship also fit any decor. Call 1-800-451-7247 for our free 16-page catalog or visit www.kleindesign.com.

[kleindesign.com](http://www.kleindesign.com)



BIRD & ANIMAL CONTROL PRODUCTS

Keep those pesky birds and animals from defacing your property with Nixalite stainless steel strips. Nixalite prevents birds from landing and roosting on windowsills, ledges, roof peaks or most any surface where they're not wanted. Free catalog of effective bird and wildlife control products. 1-800-624-1189.

www.nixalite.com



Before



After

ADD-ON WINDOW PANES

For patio doors, tool Decorative vinyl grids are easy to install, inexpensive, removable and durable. You make them fit any size or make of window or door without tools. Homeowners love the new look and SAVE. Color brochures show how, prices and other homes. 1-800-382-7263. Free catalog.

newpanes.com



ROLBAK®

The original basketball protection net system. Provides safer play, property protection, excellent free throw training aid, returns ball back towards the shooter. Universal fit to all basketball apparatus. SGMA - Voted TOP 5 Sports Product of the Year. \$47.95 - \$99.95. Dicon Rose Inc./RolBak 1-877-765-2257.

www.rolbak.com



EXERCISE IN ONLY 4 MINUTES PER DAY

The fastest, best exercise machine was given the Popular Science "Best of What's New" award in December of 1991. Yet the established exercise "experts" elite stubbornly persist that a 4-minute cardio exercise is impossible. They are very WRONG. Very expensive. Free Video. 1-818-787-6460 Fax: 1-818-787-6470.

www.QuickGym.com

IN THE SPIRIT OF THE WRIGHT BROTHERS:
A series of articles and events examining

the **FUTURE** of
POPULAR SCIENCE AVIATION

December 2003 will mark the centenary of the Wright Brothers' flight at Kitty Hawk. Leading up to this important anniversary, Popular Science is publishing a series of articles celebrating the spirit of invention, innovation and adventure that led to the triumphant first flight. We will also publish a special Future of Aviation issue in November. This issue will feature the results of an important roundtable where leading aviation experts will discuss the breakthroughs and challenges that will shape aviation in the decades ahead.

THE POPULAR SCIENCE
FUTURE OF AVIATION ROUNDTABLE

FEATURING:

MIKE BENZAKEIN	MARK MOORE
» GE Aircraft Engines	» NASA
ADAM BROWN	GEORGE MUELLNER
» Airbus	» Boeing
PETER DIAMANDIS	BURT RUTAN
» X PRIZE Foundation	» Scaled Composites, Inc.
PAUL MACCREADY	
» AeroVironment	

In partnership with:



XYPEX HD-150



Apply to wet concrete • Won't blister or peel

Xypex Crystalline Technology penetrates deep into the concrete to form a non-soluble crystalline structure that stops leaks permanently.

little time for reaction lag, and even though the laser's hardware generates a pulse to trigger Nebeker's camera at the same time that it triggers the laser, the circuitry and the 20-foot cable attaching laser to camera add nanoseconds of delay here and there.

In order to capture the image, Nebeker has to measure and synchronize the delay of the laser with the delay of the camera. Employing a trial-and-error process, he ultimately gets the camera to switch on precisely while the pulse is passing through the mirrors. As predicted, a 100-nanosecond exposure produces an image showing, in the first frame, the entire 90-foot course lit up; the second frame is dark. He then cuts exposure time down to 50 nanoseconds, which produces a first-frame image showing half the course illuminated. The second frame, however, remains dark. Tweaking the delay between frames, he produces a second frame that shows the tail end of the pulse disappearing into the terminating "beam dump" box at the far end of the mirror course.

Nebeker adjusts the exposure time to 10 nanoseconds, the camera's limit, and the attending Spectra-Physics engineers begin to get excited about what they're seeing. As expected, the computer screen shows a first frame in which only one leg of the mirror course has laser light in it. The rest is dark. In the second frame, also 10 nanoseconds long and exposed after 10 nanoseconds' delay, a leg of the course two over from the first is illuminated. Nebeker has captured two discrete portraits of a laser light beam traveling within the 90-foot course.

The grainy black-and-white digital images would not pass muster with John Woo. Nonetheless, they show light the way science fiction has long depicted it—moving as a discrete packet across a short space (think of Kirk's phaser, set to stun, in the old *Star Trek*). The small crowd of engineers is delighted. "I think we need one of those!" one engineer calls out as he looks longingly at the Cordin Model 220 camera.

This was a gee-whiz shot, no question: The Cordin camera managed to freeze light in its tracks, as if it were no faster, say, than a speeding bullet. ■

Ethan Smith, a New York City-based journalist, writes about culture, business, politics and science.

THE PERMANENT SOLUTION TO CONCRETE LEAKS

Xypex Chemical Corporation Tel: 604-273-5265 Fax: 604-270-0451 Toll Free: 800-961-4477
Email: info@xypex.com Website: www.xypexhd-150.com

Ban Telemarketers From Your Home Forever!

PhoneZap is the only technology that stops telemarketers BEFORE the phone rings.

You've had a long day and look forward to coming home and finding some peace of mind. You're just beginning to feel relaxed as you sit down to dinner. Of course the phone rings. Maybe you will



just let the machine answer. But then you are reminded that your son is driving home in bad weather or your mother lives alone; maybe it's about her health. In a fit of panic you jump up to answer the phone.

"Hello, is Mr. or Mrs. Smith at home?" ... You know immediately that someone who wants to sell you a new long distance service, aluminum siding or a new credit card has pried you from your din-

ner table. Now you can say hello to regaining your privacy with Phone Zap.

PhoneZap's technology disconnects 100% of those annoying calls before they ring through. That means your phone won't even ring if it's a telemarketer, but all of your personal calls will get through. No more unlawful phone scams or unwanted calls. Even the new "Do Not Call" lists exempt many of the most annoying telemarketers such as banks, stock brokers and politicians but PhoneZap blocks them too.

PhoneZap is so much more effective than the Telezapper®. The Telezapper® can only block computer-generated calls meaning that millions of calls still get through.

PhoneZap Platinum also acts as a caller ID. Just connect the Phone-Zap in line with any phone and you've regained your privacy. It's that simple. PhoneZap puts the law to work for you!

This is a direct offer in conjunction with PhoneZap and is not available in stores. It comes with our 30 day money-back guarantee; if you're not completely satisfied, simply return it for the full purchase price.

Why We Zap Better

Stops telemarketers before phone rings

Stops all telemarketers

No annoying beeping noises

Blocks 100% of telemarketing

No telemarketing calls at dinner

Caller ID



How often does your dinner get interrupted by telemarketers?

Not available in stores.

Call now to take advantage of our special direct offer.

PhoneZap

~~\$49.95~~ \$49.95 + S&H.

Promotional Code PHZ131

Please mention this when you call.

Toll-Free 24 hours a day

1-800-859-1518.

To order by mail, please call for details.



We also accept your check by phone.

Telezapper® is a registered trademark of Royal Appliance Mfg. Co.

NEXTTEN
products for your next ten years.

14101 Southcross Drive W.
Dept. PHZ131
Burnsville, Minnesota 55337

For fastest service, call toll-free 24 hours a day **800-859-1518**

ENERGY-SAVING SUNPORCH CONVERTIBLE® SUNROOM/SCREENROOM

READY TO
ASSEMBLE KIT MOUNTS ON
DECKS, PATIOS, OR LANDSCAPE TIES



Full Height Wall Screens!

- QWIK® window/screen change system
- Meets building codes
- Climate Control System
- No extras, comes complete
- Buy factory direct & save □ America's #1 value since 1974.

BUILD
& PRICE
ONLINE

DOWNLOAD CATALOG & PRICES

www.sunporch.com (Web Code POS)

OR MAIL \$2.
for Catalog & Prices.

SunPorch® Structures Inc.
P.O. Box 368, Dept. POS
Westport, CT 06881-0368



Swim At Home™



Swim or exercise against a smooth current adjustable to any speed or ability. Ideal for swimming, water aerobics, rehabilitation and fun. The 8' x 15' Endless Pool™ is simple to maintain, economical to run, and easy to install inside or outdoors.

For Free DVD or Video Call
(800) 233-0741, Ext. 2872

Visit www.endlesspools.com/2872
or write Endless Pools, Inc.
200 E Dutton Mill Road
Aston, PA 19014



DISCOVER THE GREAT INDOORS!

Now is the time for a Timberline Geodesic Dome. Combining vaulted ceilings with natural light, energy savings of up to 40% and an affordable building system, Timberline Domes are perfect for any location.

Our many designs provide an open, spacious feeling with traditional style. With floor plans ranging from 1,000 to over 4,000 square feet, you're sure to find one to fit your lifestyle.



A Timberline Dome can easily be assembled by two people without previous construction experience. In fact, over 90% of our customers assemble the dome themselves. Our patented Heavy-Duty Connector system and pre-cut, color coded lumber make building a breeze.

With all these advantages, isn't it time you discovered the great indoors? Our planning package includes color photos, floor plans, assembly instructions, pricing and technical information. Call or send for our full color planning package today.

1-800-Dome Home
or visit us on the internet at:
www.domehome.com



Please Send Me The Following Information.

- Planning Package and Video Together: \$22.00 Planning Package: \$12.00 Video: \$19.00

Check Visa MC Discover Credit Card No: _____

Name: _____

Address: _____

City: _____

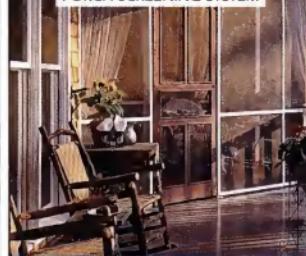
State: _____



The BETTER Way to Screen

SCREEN TIGHT™

PORCH SCREENING SYSTEM



Maintenance Free Quick & Affordable

Just Think...

- No Sagging Screens
- No Painting Outside Trim
- No Rusty Nails or Staples

As Easy As
1, 2, SCREEN!



1. Attach base strip to existing frame (cuts to fit with shears)
2. Roll screen into base strip w/spline & screen roller
3. Snap cap trim into place on top of base strip

Call for your FREE
SAMPLE Today!
1.800.768.7325

www.screentight.com

Available at Home Improvement &
Hardware Stores Everywhere!

SECURE YOUR OWN **PURE** WATER SUPPLY

Now you don't have to worry about failures in water supply systems. You can have your very own **self-sustaining source of water**.

Since 1962, thousands of gardeners and homeowners around the world have discovered the **Hydra-Drill™** secret. They drilled their own wells!

You can too. Call or write us today and we'll send you a big, free package of information about drilling your own well with the **Hydra-Drill™**



Ask about our "How to..." video!

Call Today for FREE Water Well Drilling Information Package

1-800-333-7762

ask for operator 8519
www.deeprock.com

Try our DR® FIELD and BRUSH MOWER for RISK-FREE!

Test this amazing, self-propelled, walk-behind brush cutter on your property to—

- **CLEAR & MAINTAIN** meadows, pastures, roadsides, fence lines, walking paths with ease!
- **CUT tall grass, weeds, brush**—even saplings up to 2-1/2" thick!
- **CHOP/MULCH** most everything you cut!

FREE SHIPPING now in effect!

If it's not the best machine for clearing fields and brush you've ever used, we'll take it back and you won't be out a penny. We'll even pay for shipping both ways! For details—

CALL 1-800-454-6400

TEST: Please send me your free Catalog, including details on how I can try out the DR® FIELD and BRUSH MOWER RISK-FREE!

Name _____
Address _____
City _____ State _____ Zip _____

Email _____

 COUNTRY HOME PRODUCTS®, Dept. 46254X

Meigs Rd., P.O. Box 25, Vergennes, VT 05491

www.drfieldbrush.com

We make installing a spiral straightforward.



Metal Spirals
from
\$425

- Diameters 3'6" to 7'0"
- Kits or Welded Units

Oak Spirals
from
\$1575

- Diameters 4'0" to 6'0"
- All Oak Construction

Victorian One®
from
\$3300

- Diameters 4'0" to 6'0"
- Cast Aluminum Construction

The best selection, quality, and prices!

Since 1931, The Iron Shop has enjoyed a reputation for outstanding design and fabrication of spiral stairs. Today, we utilize computer-aided technology throughout our production process successfully mixing state-of-the-art manufacturing with Old World quality. Offering the largest selection, highest quality, and lowest prices in spiral stairs—we make sure that you get the right spiral to meet your needs, available in any height and BOCA/UBC code models. And our spirals are still made with pride in the U.S.A.

Call for the FREE color Catalog & Price List:

1-800-523-7427 Ask for Ext. PS
or visit our Web Site at www.TheIronShop.com/PS

Main Plant & Showroom: Dept. PS, P.O. Box 547, 400 Reed Rd. Broomall, PA 19008
Showrooms / Warehouses: Ontario, CA • Sarasota, FL • Houston, TX • Chicago, IL • Stamford, CT

*Installation Video featuring
"The Furniture Guys"
included with all Metal & Oak
Spiral Stair Kits.*

THE IRON SHOP®

The Leading Manufacturer of Spiral Stair Kits®



©2002 The Iron Shop

VIEW OVER 800 PRODUCTS ON OUR NEW WEB SITE!



LPD-4005
Four Camera Package



Images Astronomical & Terrestrial Objects in Darkness

Ask About Our Package Deals!

Back View



Professional TCP/IP
Color Security Camera

View Office or Home

&
Record to Your Hard Drive
Over the Internet!



20

Magnified 40X



MS-140X Video Microscope
Magnifies Your Image Up To 40X
Attach to Your Monitor or PC



Polaris Industries, Inc.
470 Armour Dr., Atlanta, GA 30324

Local 404.872.0722 FAX 404.872.1038

*(Several Models Available
Call for More Information)*

Mobile Digital Video Recorder

800.411.4351

WWW.POLARISUSA.COM **800.411.4351**



COUNTRY HOME PRODUCTS®, Dept. 46254X

Meigs Rd., P.O. Box 25, Vergennes, VT 05491

www.drfieldbrush.com



Dr. Winnifred Cutler - Creator of 10X

GET MORE AFFECTION from women WITH ATHENA'S 10X™

Dr. Cutler is a biologist and President of Athena Institute, co-discoverer of human pheromones in 1986 (Time 12/1/86; Newsweek 1/12/87). Ph.D. from U. of Penn, post-doc Stanford, authored 35+ scientific papers, 6 books, and wrote the pheromone chapter in a medical textbook.



ATHENA PHEROMONE 10X™ unscented aftershave/cologne additive

✓ **Jacques (LA)** 10X order "I am a physician, read about your study in the Medical Tribune, and have been buying ever since. It's really a fine product."

✓ **Patrick (TN)** "Good morning! I recognize your voice, Dr. Cutler. You are so smart! I want 3 more vials of the 10X. I use it straight. And it works really well. The 10X makes for friendlier relationships at work. Less hostility. I have a wife who has to take medications that make her grouchy...but the 10X has worked miracles. Thanks so much for your pheromones, Dr. Cutler. It has really made a difference in our lives."

✓ **Tad (UT)** "I [was] skeptical ... I thought, well I will try this because of the scientist who developed this product. Women...say 'You smell so good!' It's pretty incredible. It works, absolutely no doubt of that."

RAISE the OCTANE of your AFTERSHAVE

10X is designed to enhance your sex-appeal. Vial of 1/6 oz. added to 2-3 oz. of your aftershave or cologne lasts 4-6 months. Contains synthesized human pheromones. Not guaranteed to work for all, since body chemistries differ, but does work for most men. Not an aphrodisiac. Patent Pending. Also: Athena Pheromone 10:13™ for women.

www.athenainstitute.com

Not in stores. Call (610) 827-2200 - Order online - or send to: Athena Institute, Dept PSV,
1211 Braefield Rd., Chester Springs, PA 19425

Please send me _____ vials of 10X for men @ \$99.50
and/or _____ vials of 10:13 for women @ \$98.50
for a "total" by: money order check
 Visa/MC/Disc. _____
exp. _____ signature _____
to: Name _____
Address _____
City/State _____ zip _____
Phone: _____ email _____
PSV
*P&P add 6% tax, Canada add US \$7.50 per vial

The Natural Solution for:

- Cabins & Cottages
- Barns
- Basements
- Pool Houses
- Boat Houses
- Garages
- Nearly ANYWHERE!

- No Water!
- No Sewer!
- No Odors!
- No Chemicals!

To receive free information, call:

1-800-5BioLet ext 220

(800-524-6538 ext 220)

or visit us on the web:

www.biiolet.com



BioLet
Composting Toilets

Waterless Solutions

The Best-Selling Composting Toilet In The World!

BioLet USA, Inc. • PO Box 548 • Newcomerstown, OH 43832

Discover H₂Omemade purity

Others filter...WE PURIFY

- ✓ Simple home appliance eliminates contaminants
- ✓ Purity Guaranteed 100% distilled
- ✓ Pure Savings eliminate bottled
- ✓ Pure Integrity tested & certified

Call today for your **FREE** Info Packet

1-800-874-9028

www.waterwise.com

© 2002 Waterwise Inc

VIAGRA®

Access Rx
MEDICATIONS ONLINE

Life has many decisions,
choose to start yours over...

Call now and ask our
operators about our specials



U.S. licensed doctor • Over 50,000 clients • Discreet and secure overnight

Call us Toll Free

1-800-930-8770

24 Hours a day 7 Days a week

www.accessrx.com



DRIVERS:
 ▶ ATC
 ▶ AUDAX
 ▶ TON
 ▶ FOSTEX
 ▶ LPG
 ▶ MOREL
 ▶ SEAS
 ▶ VIFA
 ▶ VOLT
 ▶ PEERLESS
 ▶ MAX FIDELITY
 ▶ SCAN-SPEAK
 ▶ ILLUSION AU

- HARDWARE
- COMPONENTS
- HOW TO BOOKS
- CUSTOM COMPUTER AIDED CROSSOVER AND CABINET DESIGN

Call, write, email or fax for the Solen Catalog.

An \$8.00 purchase price will be charged to non-professionals and discounted off the first order over \$50.00. Businesses and professionals may request one copy free of charge.



SOLEN, INC.
 4470 Avenue Thibault
 St-Hubert, QC, J3Y 7T9 CANADA

Tel: 450.656.2759
 Fax: 450.443.4949
 Email: solen@solen.ca
 Web: www.solen.ca



Are you losing your hair?

If so, there's finally good news!

Clinically proven hair restoration system is so effective, it is awarded U.S. patent!



Proven Patented Formula Stops Hair Loss and Re-Grows New Hair!

It is commonly known that the major cause of hair loss is due to the build up of the "bad hormone" Dihydrotestosterone(DHT). Clinical trials prove that when used together, the powerful ingredients in Prolific™ prevent the build up of DHT, stopping your hair loss and allowing your follicles to strengthen and reproduce strong healthy hairs. We are proud to announce that after years of clinical research and testing, Prolific's™ scientifically advanced formula is now available to the general public. This highly effective formula is so advanced it has even been awarded a U.S. patent number. (Reference U.S. Patent number 5,972,345)

Stop worrying about your hair loss, Do something about it!

If you fear that your thinning hair will eventually leave you bald or you are tired of watching your hairline recede, you can stop worrying! Get Prolific™ and take action. This patented formula will stop your hair from falling out and even grow back the hair you've lost, guaranteed! Now, for a limited time you can try Prolific™ risk free for 90 days. Call now for more information and be sure to mention offer # 617.

Now you can try Prolific™ absolutely risk free!

You don't have to live with thinning hair! Now you can try Prolific™ absolutely risk-free for 90 days! Put this revolutionary formula to work for you. Take action and call now! Get back your youthful hairline with ease and confidence! Call now, toll-free 1-800-519-7868 offer# 601.

Get Prolific™ and get ready to look and feel younger!

Doctor recommended for both men and women!

prolific™



Call Now! Try Prolific™ risk free for 90 days!

1-800-519-7868 Offer # 617

The #1 Sensual Products CATALOG

Your invitation to a whole new realm of pleasure possibilities!

The Xandria Collection Catalog offers a special selection of over 200 premium adult products chosen by experts for quality of craftsmanship, style, and uniqueness. Whether you're new or experienced, timid or daring, you'll find the perfect passion products to super-charge your love life!

Xandria has been in business for more than 27 years with over 2 million satisfied customers. We back our entire collection with a 100% GUARANTEE of Privacy, Quality, and Satisfaction.

Unlike most other adult products companies, all transactions with us are strictly confidential. We'll never sell, rent, or trade your name to anyone for any reason, so you won't get flooded with unwanted mailings!

Xandria Collection

Dept. PSC0703, P.O. Box 31039, San Francisco, CA 94131-9988

Enclosed is my check or money order for \$4 (55 Canada, £3 UK). Please send me the Xandria Gold Edition Catalog and a coupon good for \$4 OFF my first purchase.

I am over 21.
 Signature required _____

Name _____

Address _____

City _____

State/Zip _____

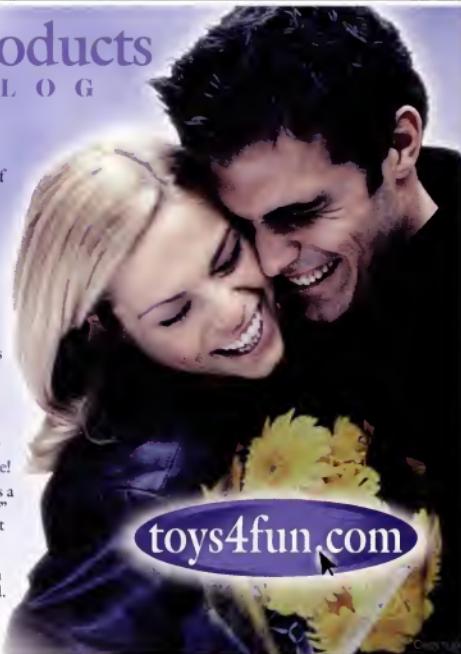
Email Address _____

Xandria, 165 Valley Dr., Brisbane, CA 94005-1340 Void where prohibited by law.

Two ways to receive \$4 OFF your first purchase!

- Identify yourself as a "First Time Buyer" during checkout at xandria.com, then type the discount code PSC0703 in the space provided.
- Purchase a catalog by mail (see coupon).

toys4fun.com



Central Air Conditioning

Do-It-Yourself!

only **\$895.00**

24,000 BTUs, 10 SEER

Free Shipping!
(in continental USA)



Free Installation Video!

- Top Brands
- Weekend Project
- High Efficiency Units
- Complete Kit Delivered Right to your Door
- Up to 10 Year Warranty
- Unlimited Online Technical Support

**Buy online and save!
www.Buy-AC.com**
Alpine Home Air Products



Emergency Power For Your Cell Phone

Portable Hand Powered Charger Really Works!

- Works With Most Cell Phones
- Built-In White LED Light

\$24⁹⁹
FREE Shipping



FREE CATALOG

C. CRANE COMPANY

800-522-8863 • ccrane.com

SINGERS! REMOVE VOCALS
Unlimited Free Backgrounds
from Original Standard Recordings!
Thompson Vocal Eliminator™
VE-4 Free Brochure/Demo
24 Hour Demo/Info Line
(770)482-2485 Ext 60
LT Sound Dept PSC 100 LT Parkway, Lithonia, GA 30058
www.ltsound.com **SELLING TO COMPANIES Better Than Karaoke For Over 25 Years!**



The Mantis™ Bluetooth Analyzer

- Identify, install & verify Bluetooth wireless devices and connections
- Reports RSSI signal strength in true dBm
- Measures Packet Error Rate (PER)

BERKELEY VARIOTICS
SYSTEMS
METUCHEN, NJ 08840

Call today:
(732) 548-3737

www.bvsystems.com



Priced under \$1,000

Slide-to-Photo™



Memories last forever, but 35mm slides don't.
Convert 35mm slides super-fast, easily and inexpensively.

Using your digital camera, slide projector, and our Slide-to-Photo™ device, you can preview and capture those images in digital format, share them with others and enjoy them for a lifetime for under \$50.

Visit our website at www.slidetophoto.com

"Why Men All Over America Love Testostazine!"



"After a few weeks of taking Testostazine, my wife and I felt like we were back on our honeymoon again. And after 35 years, that's quite an accomplishment."

John - Manhasset, NY

"When I tried Testostazine, I thought, 'Wow! I've got a lot more energy and my sex drive is increased.'"

Gary - Mesa, AZ

Powerful Male Performance Boosting System Lets You Be All the Man You Can Be

Do you feel like half the man you used to be? Are you enjoying intimacy a lot less than you'd like? Do you lack confidence in the bedroom?

If so, you could have low testosterone.

In many men, testosterone levels can fall rapidly as you age, leaving you feeling like half the man you used to be.

That's why I created the Testostazine System. It's the complete performance boosting system I developed for men who are starting to feel their age.

Are You Man Enough? Now You Can Be

I designed Testostazine to support healthy testosterone levels, so you can be all the man you want to be...when you need to be. Testostazine was once only available to patients through my private practice. Now it's available to the general public...confidentially and without a prescription.

If you feel like half the man you used to be, don't give up. I can help you regain your youthful stamina and drive.

Best regards,

R. Cohen, M.D.

Dr. Richard Cohen

Call now for your risk-free trial

1-800-556-4050

testostazine™



Join Mr. Arbor™ and Plant Trees

10 Free Trees for Wildlife

Join The National Arbor Day Foundation, and receive 10 Free Trees for Wildlife.

Your trees will protect the environment, shelter wildlife, and provide food for more than 100 species of songbirds. They will be shipped postpaid at the right time for planting in your area, February through May in the spring or October through mid December in the fall.

Send your \$10 contribution to 10 Trees for Wildlife, The National Arbor Day Foundation, 100 Arbor Avenue, Nebraska City, NE 68410.



**The National
Arbor Day Foundation®**

www.arborday.org

INDIVIDUAL RESULTS WILL VARY. THESE STATEMENTS HAVE NOT BEEN EVALUATED BY THE FOOD AND DRUG ADMINISTRATION AND ARE NOT INTENDED TO DIAGNOSE, CURE OR PREVENT ANY DISEASE. 1-800-556-4050 © 2002 West Brook, Inc.

psdirect

to advertise call Joan Orth at
(800) 445-2714 ext. 5555 or (212) 779-5555

NORWOOD
INDUSTRIES INC.

PORTABLE BAND SAWMILLS

LUMBERMATE™ 2000



From
\$3,895.

Call today for more details!

1-800-661-7746 Ext. 350

Norwood Industries Inc. • 252 Sonnen Drive, Buffalo, NY U.S.A. 14225

30' x 40' x 10'
\$4,462

We Ship Anywhere In The USA!!! 10,000 Items. Bolt-Together All Steel Buildings & Homes. Call Today For A Price Quote And Brochure.

HERITAGE BUILDING SYSTEMS®
800.643.5555
heritagebuildings.com

2 SEAT BIKE DRIVES LIKE A CAR



- Easy to Pedal
- Multi-Speed
- Street Legal
- 1, 2 & 4 Seaters

1-615-822-2737 Ext. 5786 • www.4wc.com/75796
RHODES CAR Dept. 5786 • 125 Rhodes Lane Hendersonville, Tennessee 37075

FACTORY DIRECT STEEL BUILDINGS SAVE HUNDREDS OF DOLLARS



SAVE HUNDREDS OF DOLLARS
ADDITIONAL SIZES AVAILABLE

800-547-8335



FUTURE STEEL BUILDINGS

FACTORY-DIRECT WHOLESALE PRICES!!



1-800-668-5111 ext. 1508

air, space & outerspace

BalloonCraft
\$79.95

E-GULL 2CH
w/Radio
\$89.95

T-HAWK 3CH
w/Radio
\$129.95

**Easy-To-Fly!
Affordable!
Fun!**

www.ReadyToFlyFun.com
Toll Free 1-866-472-8697

Popular Science reserves the right to refuse any advertising order. Only publication of an advertisement shall constitute final acceptance of an order. Publication does not constitute an agreement for continued publication. All orders are subject to the applicable rate card, copies of which are available upon written request sent to the address provided. Popular Science, 2 Park Avenue, New York, NY 10016

MEN...LOOK TALLER!



ELEVATORS® Shoes that make you appear up to 3' taller. Over 100 styles. Money Back Guarantee. Hidden height increaser inside shoes. Making men taller since 1939. Call or write for FREE color catalog.
www.elevatorshoes.com/1.htm

ELEVATORS®

RICHLEE SHOE CO., DEPT. P537
P.O. BOX 3566, FREDERICK, MD 21705

1-800-343-3810

30' x 40' x 10'
\$4,462

We Ship Anywhere In The USA!!! 10,000 Items. Bolt-Together All Steel Buildings & Homes. Call Today For A Price Quote And Brochure.

HERITAGE BUILDING SYSTEMS®
800.643.5555
heritagebuildings.com

STEELMASTER
ECONOMY • QUALITY • INTEGRITY

STEEL BUILDINGS

Build It Yourself & SAVE!



COLOR ENDWALLS • MAINTENANCE FREE • 100% USEABLE SPACE

Workshops • Equipment Storage • Boat Storage • RV Shelters

1-800-341-7007 for FREE Brochure
www.steelmasterusa.com

OVER 25 YEARS OF ENGINEERING EXCELLENCE

The Monolithic™ Dome

A super strong, steel-reinforced, insulated, concrete building that is energy efficient and durable. Used for homes, small businesses, schools, churches, offices, medium storage, caves, and more. Built throughout the U.S. and in many countries, the Monolithic™ Dome is tomorrow's building awaits today.

monolithic.com

HYDROGEN HAWAII: HYDROGEN VEHICLES & FUEL CELLS ON DVD

Feature length 90-min. PLAY IN ALL COUNTRIES \$19.95

DVD VIDEO \$24.95
VHS \$19.95
Call 800-668-5111 for shipping

FOR UNDER \$10K

Email: sales@monolithic.com
Assembly time approx. 500 hrs.

Homebuilt HELICOPTERS 2 for 1 Special
G-1 400 Kiteflier IIIC EYCAM
Only \$25.99!
(Add \$4 post, Foreign add \$8)
(For Catalog only, send \$10)

24-HOUR ORDERING:
www.monolithic.com/order
BY PHONE: 1-800-668-5111
VORTech, Inc. • PO Box 5114 • Fallston, MD 21047 • USA

INcredible Wireless Flying Videocamera

It's cool and completely unique.
MAKES MONEY HIGH TECH SPY VIDEO SURVEILLANCE

THE DRAGONFLYER III EYCAM
ORDER NOW! 1-877-576-5764 • Dreyguss Innovations • EYCAM.COM
CATALOG #2 • 5104A St. George Ave. Mississauga, ON L5M 1R2 CANADA

FOR UNDER \$10K

Email: sales@monolithic.com
Assembly time approx. 500 hrs.

Homebuilt HELICOPTERS 2 for 1 Special
G-1 400 Kiteflier IIIC EYCAM
Only \$25.99!
(Add \$4 post, Foreign add \$8)
(For Catalog only, send \$10)

24-HOUR ORDERING:
www.monolithic.com/order
BY PHONE: 1-800-668-5111
VORTech, Inc. • PO Box 5114 • Fallston, MD 21047 • USA

FOR UNDER \$10K

Email: sales@monolithic.com
Assembly time approx. 500 hrs.

Homebuilt HELICOPTERS 2 for 1 Special
G-1 400 Kiteflier IIIC EYCAM
Only \$25.99!
(Add \$4 post, Foreign add \$8)
(For Catalog only, send \$10)

24-HOUR ORDERING:
www.monolithic.com/order
BY PHONE: 1-800-668-5111
VORTech, Inc. • PO Box 5114 • Fallston, MD 21047 • USA

FOR UNDER \$10K

Email: sales@monolithic.com
Assembly time approx. 500 hrs.

Homebuilt HELICOPTERS 2 for 1 Special
G-1 400 Kiteflier IIIC EYCAM
Only \$25.99!
(Add \$4 post, Foreign add \$8)
(For Catalog only, send \$10)

24-HOUR ORDERING:
www.monolithic.com/order
BY PHONE: 1-800-668-5111
VORTech, Inc. • PO Box 5114 • Fallston, MD 21047 • USA

FOR UNDER \$10K

Email: sales@monolithic.com
Assembly time approx. 500 hrs.

Homebuilt HELICOPTERS 2 for 1 Special
G-1 400 Kiteflier IIIC EYCAM
Only \$25.99!
(Add \$4 post, Foreign add \$8)
(For Catalog only, send \$10)

24-HOUR ORDERING:
www.monolithic.com/order
BY PHONE: 1-800-668-5111
VORTech, Inc. • PO Box 5114 • Fallston, MD 21047 • USA

FOR UNDER \$10K

Email: sales@monolithic.com
Assembly time approx. 500 hrs.

Homebuilt HELICOPTERS 2 for 1 Special
G-1 400 Kiteflier IIIC EYCAM
Only \$25.99!
(Add \$4 post, Foreign add \$8)
(For Catalog only, send \$10)

24-HOUR ORDERING:
www.monolithic.com/order
BY PHONE: 1-800-668-5111
VORTech, Inc. • PO Box 5114 • Fallston, MD 21047 • USA

FOR UNDER \$10K

Email: sales@monolithic.com
Assembly time approx. 500 hrs.

Homebuilt HELICOPTERS 2 for 1 Special
G-1 400 Kiteflier IIIC EYCAM
Only \$25.99!
(Add \$4 post, Foreign add \$8)
(For Catalog only, send \$10)

24-HOUR ORDERING:
www.monolithic.com/order
BY PHONE: 1-800-668-5111
VORTech, Inc. • PO Box 5114 • Fallston, MD 21047 • USA

FOR UNDER \$10K

Email: sales@monolithic.com
Assembly time approx. 500 hrs.

Homebuilt HELICOPTERS 2 for 1 Special
G-1 400 Kiteflier IIIC EYCAM
Only \$25.99!
(Add \$4 post, Foreign add \$8)
(For Catalog only, send \$10)

24-HOUR ORDERING:
www.monolithic.com/order
BY PHONE: 1-800-668-5111
VORTech, Inc. • PO Box 5114 • Fallston, MD 21047 • USA

FOR UNDER \$10K

Email: sales@monolithic.com
Assembly time approx. 500 hrs.

Homebuilt HELICOPTERS 2 for 1 Special
G-1 400 Kiteflier IIIC EYCAM
Only \$25.99!
(Add \$4 post, Foreign add \$8)
(For Catalog only, send \$10)

24-HOUR ORDERING:
www.monolithic.com/order
BY PHONE: 1-800-668-5111
VORTech, Inc. • PO Box 5114 • Fallston, MD 21047 • USA

FOR UNDER \$10K

Email: sales@monolithic.com
Assembly time approx. 500 hrs.

Homebuilt HELICOPTERS 2 for 1 Special
G-1 400 Kiteflier IIIC EYCAM
Only \$25.99!
(Add \$4 post, Foreign add \$8)
(For Catalog only, send \$10)

24-HOUR ORDERING:
www.monolithic.com/order
BY PHONE: 1-800-668-5111
VORTech, Inc. • PO Box 5114 • Fallston, MD 21047 • USA

FOR UNDER \$10K

Email: sales@monolithic.com
Assembly time approx. 500 hrs.

Homebuilt HELICOPTERS 2 for 1 Special
G-1 400 Kiteflier IIIC EYCAM
Only \$25.99!
(Add \$4 post, Foreign add \$8)
(For Catalog only, send \$10)

24-HOUR ORDERING:
www.monolithic.com/order
BY PHONE: 1-800-668-5111
VORTech, Inc. • PO Box 5114 • Fallston, MD 21047 • USA

FOR UNDER \$10K

Email: sales@monolithic.com
Assembly time approx. 500 hrs.

Homebuilt HELICOPTERS 2 for 1 Special
G-1 400 Kiteflier IIIC EYCAM
Only \$25.99!
(Add \$4 post, Foreign add \$8)
(For Catalog only, send \$10)

24-HOUR ORDERING:
www.monolithic.com/order
BY PHONE: 1-800-668-5111
VORTech, Inc. • PO Box 5114 • Fallston, MD 21047 • USA

FOR UNDER \$10K

Email: sales@monolithic.com
Assembly time approx. 500 hrs.

Homebuilt HELICOPTERS 2 for 1 Special
G-1 400 Kiteflier IIIC EYCAM
Only \$25.99!
(Add \$4 post, Foreign add \$8)
(For Catalog only, send \$10)

24-HOUR ORDERING:
www.monolithic.com/order
BY PHONE: 1-800-668-5111
VORTech, Inc. • PO Box 5114 • Fallston, MD 21047 • USA

FOR UNDER \$10K

Email: sales@monolithic.com
Assembly time approx. 500 hrs.

Homebuilt HELICOPTERS 2 for 1 Special
G-1 400 Kiteflier IIIC EYCAM
Only \$25.99!
(Add \$4 post, Foreign add \$8)
(For Catalog only, send \$10)

24-HOUR ORDERING:
www.monolithic.com/order
BY PHONE: 1-800-668-5111
VORTech, Inc. • PO Box 5114 • Fallston, MD 21047 • USA

FOR UNDER \$10K

Email: sales@monolithic.com
Assembly time approx. 500 hrs.

Homebuilt HELICOPTERS 2 for 1 Special
G-1 400 Kiteflier IIIC EYCAM
Only \$25.99!
(Add \$4 post, Foreign add \$8)
(For Catalog only, send \$10)

24-HOUR ORDERING:
www.monolithic.com/order
BY PHONE: 1-800-668-5111
VORTech, Inc. • PO Box 5114 • Fallston, MD 21047 • USA

FOR UNDER \$10K

Email: sales@monolithic.com
Assembly time approx. 500 hrs.

Homebuilt HELICOPTERS 2 for 1 Special
G-1 400 Kiteflier IIIC EYCAM
Only \$25.99!
(Add \$4 post, Foreign add \$8)
(For Catalog only, send \$10)

24-HOUR ORDERING:
www.monolithic.com/order
BY PHONE: 1-800-668-5111
VORTech, Inc. • PO Box 5114 • Fallston, MD 21047 • USA

FOR UNDER \$10K

Email: sales@monolithic.com
Assembly time approx. 500 hrs.

Homebuilt HELICOPTERS 2 for 1 Special
G-1 400 Kiteflier IIIC EYCAM
Only \$25.99!
(Add \$4 post, Foreign add \$8)
(For Catalog only, send \$10)

24-HOUR ORDERING:
www.monolithic.com/order
BY PHONE: 1-800-668-5111
VORTech, Inc. • PO Box 5114 • Fallston, MD 21047 • USA

FOR UNDER \$10K

Email: sales@monolithic.com
Assembly time approx. 500 hrs.

Homebuilt HELICOPTERS 2 for 1 Special
G-1 400 Kiteflier IIIC EYCAM
Only \$25.99!
(Add \$4 post, Foreign add \$8)
(For Catalog only, send \$10)

24-HOUR ORDERING:
www.monolithic.com/order
BY PHONE: 1-800-668-5111
VORTech, Inc. • PO Box 5114 • Fallston, MD 21047 • USA

FOR UNDER \$10K

Email: sales@monolithic.com
Assembly time approx. 500 hrs.

Homebuilt HELICOPTERS 2 for 1 Special
G-1 400 Kiteflier IIIC EYCAM
Only \$25.99!
(Add \$4 post, Foreign add \$8)
(For Catalog only, send \$10)

24-HOUR ORDERING:
www.monolithic.com/order
BY PHONE: 1-800-668-5111
VORTech, Inc. • PO Box 5114 • Fallston, MD 21047 • USA

FOR UNDER \$10K

Email: sales@monolithic.com
Assembly time approx. 500 hrs.

Homebuilt HELICOPTERS 2 for 1 Special
G-1 400 Kiteflier IIIC EYCAM
Only \$25.99!
(Add \$4 post, Foreign add \$8)
(For Catalog only, send \$10)

24-HOUR ORDERING:
www.monolithic.com/order
BY PHONE: 1-800-668-5111
VORTech, Inc. • PO Box 5114 • Fallston, MD 21047 • USA

FOR UNDER \$10K

Email: sales@monolithic.com
Assembly time approx. 500 hrs.

Homebuilt HELICOPTERS 2 for 1 Special
G-1 400 Kiteflier IIIC EYCAM
Only \$25.99!
(Add \$4 post, Foreign add \$8)
(For Catalog only, send \$10)

24-HOUR ORDERING:
www.monolithic.com/order
BY PHONE: 1-800-668-5111
VORTech, Inc. • PO Box 5114 • Fallston, MD 21047 • USA

FOR UNDER \$10K

Email: sales@monolithic.com
Assembly time approx. 500 hrs.

Homebuilt HELICOPTERS 2 for 1 Special
G-1 400 Kiteflier IIIC EYCAM
Only \$25.99!
(Add \$4 post, Foreign add \$8)
(For Catalog only, send \$10)

24-HOUR ORDERING:
www.monolithic.com/order
BY PHONE: 1-800-668-5111
VORTech, Inc. • PO Box 5114 • Fallston, MD 21047 • USA

FOR UNDER \$10K

Email: sales@monolithic.com
Assembly time approx. 500 hrs.

Homebuilt HELICOPTERS 2 for 1 Special
G-1 400 Kiteflier IIIC EYCAM
Only \$25.99!
(Add \$4 post, Foreign add \$8)
(For Catalog only, send \$10)

24-HOUR ORDERING:
www.monolithic.com/order
BY PHONE: 1-800-668-5111
VORTech, Inc. • PO Box 5114 • Fallston, MD 21047 • USA

FOR UNDER \$10K

Email: sales@monolithic.com
Assembly time approx. 500 hrs.

Homebuilt HELICOPTERS 2 for 1 Special
G-1 400 Kiteflier IIIC EYCAM
Only \$25.99!
(Add \$4 post, Foreign add \$8)
(For Catalog only, send \$10)

24-HOUR ORDERING:
www.monolithic.com/order
BY PHONE: 1-800-668-5111
VORTech, Inc. • PO Box 5114 • Fallston, MD 21047 • USA

FOR UNDER \$10K

Email: sales@monolithic.com
Assembly time approx. 500 hrs.

Homebuilt HELICOPTERS 2 for 1 Special
G-1 400 Kiteflier IIIC EYCAM
Only \$25.99!
(Add \$4 post, Foreign add \$8)
(For Catalog only, send \$10)

24-HOUR ORDERING:
www.monolithic.com/order
BY PHONE: 1-800-668-5111
VORTech, Inc. • PO Box 5114 • Fallston, MD 21047 • USA

FOR UNDER \$10K

Email: sales@monolithic.com
Assembly time approx. 500 hrs.

Homebuilt HELICOPTERS 2 for 1 Special
G-1 400 Kiteflier IIIC EYCAM
Only \$25.99!
(Add \$4 post, Foreign add \$8)
(For Catalog only, send \$10)

24-HOUR ORDERING:
www.monolithic.com/order
BY PHONE: 1-800-668-5111
VORTech, Inc. • PO Box 5114 • Fallston, MD 21047 • USA

FOR UNDER \$10K

Email: sales@monolithic.com
Assembly time approx. 500 hrs.

Homebuilt HELICOPTERS 2 for 1 Special
G-1 400 Kiteflier IIIC EYCAM
Only \$25.99!
(Add \$4 post, Foreign add \$8)
(For Catalog only, send \$10)

24-HOUR ORDERING:
www.monolithic.com/order
BY PHONE: 1-800-668-5111
VORTech, Inc. • PO Box 5114 • Fallston, MD 21047 • USA

FOR UNDER \$10K

Email: sales@monolithic.com
Assembly time approx. 500 hrs.

Homebuilt HELICOPTERS 2 for 1 Special
G-1 400 Kiteflier IIIC EYCAM
Only \$25.99!
(Add \$4 post, Foreign add \$8)
(For Catalog only, send \$10)

24-HOUR ORDERING:
www.monolithic.com/order
BY PHONE: 1-800-668-5111
VORTech, Inc. • PO Box 5114 • Fallston, MD 21047 • USA

FOR UNDER \$10K

Email: sales@monolithic.com
Assembly time approx. 500 hrs.

Homebuilt HELICOPTERS 2 for 1 Special
G-1 400 Kiteflier IIIC EYCAM
Only \$25.99!
(Add \$4 post, Foreign add \$8)
(For Catalog only, send \$10)

24-HOUR ORDERING:
www.monolithic.com/order
BY PHONE: 1-800-668-5111
VORTech, Inc. • PO Box 5114 • Fallston, MD 21047 • USA

FOR UNDER \$10K

Email: sales@monolithic.com
Assembly time approx. 500 hrs.

Homebuilt HELICOPTERS 2 for 1 Special
G-1 400 Kiteflier IIIC EYCAM
Only \$25.99!
(Add \$4 post, Foreign add \$8)
(For Catalog only, send \$10)

24-HOUR ORDERING:
www.monolithic.com/order
BY PHONE: 1-800-668-5111
VORTech, Inc. • PO Box 5114 • Fallston, MD 21047 • USA

FOR UNDER \$10K

Email: sales@monolithic.com
Assembly time approx. 500 hrs.

Homebuilt HELICOPTERS 2 for 1 Special
G-1 400 Kiteflier IIIC EYCAM
Only \$25.99!
(Add \$4 post, Foreign add \$8)
(For Catalog only, send \$10)

24-HOUR ORDERING:
www.monolithic.com/order
BY PHONE: 1-800-668-5111
VORTech, Inc. • PO Box 5114 • Fallston, MD 21047 • USA

FOR UNDER \$10K

Email: sales@monolithic.com
Assembly time approx. 500 hrs.

Homebuilt HELICOPTERS 2 for 1 Special
G-1 400 Kiteflier IIIC EYCAM
Only \$25.99!
(Add \$4 post, Foreign add \$8)
(For Catalog only, send \$10)

24-HOUR ORDERING:
www.monolithic.com/order
BY PHONE: 1-800-668-5111
VORTech, Inc. • PO Box 5114 • Fallston, MD 21047 • USA

FOR UNDER \$10K

Email: sales@monolithic.com
Assembly time approx. 500 hrs.

Homebuilt HELICOPTERS 2 for 1 Special
G-1 400 Kiteflier IIIC EYCAM
Only \$25.99!
(Add \$4 post, Foreign add \$8)
(For Catalog only, send \$10)

24-HOUR ORDERING:
www.monolithic.com/order
BY PHONE: 1-800-668-5111
VORTech, Inc. • PO Box 5114 • Fallston, MD 21047 • USA

FOR UNDER \$10K

Email: sales@monolithic.com
Assembly time approx. 500 hrs.

Homebuilt HELICOPTERS 2 for 1 Special
G-1 400 Kiteflier IIIC EYCAM
Only \$25.99!
(Add \$4 post, Foreign add \$8)
(For Catalog only, send \$10)

24-HOUR ORDERING:
www.monolithic.com/order
BY PHONE: 1-800-668-5111
VORTech, Inc. • PO Box 5114 • Fallston, MD 21047 • USA

FOR UNDER \$10K

Email: sales@monolithic.com
Assembly time approx. 500 hrs.

Homebuilt HELICOPTERS 2 for 1 Special
G-1 400 Kiteflier IIIC EYCAM
Only \$25.99!
(Add \$4 post, Foreign add \$8)
(For Catalog only, send \$10)

24-HOUR ORDERING:
www.monolithic.com/order
BY PHONE: 1-800-668-5111
VORTech, Inc. • PO Box 5114 • Fallston, MD 21047 • USA

FOR UNDER \$10K

Email: sales@monolithic.com
Assembly time approx. 500 hrs.

Homebuilt HELICOPTERS 2 for 1 Special
G-1 400 Kiteflier IIIC EYCAM
Only \$25.99!
(Add \$4 post, Foreign add \$8)
(For Catalog only, send \$10)

24-HOUR ORDERING:
www.monolithic.com/order
BY PHONE: 1-800-668-5111
VORTech, Inc. • PO Box 5114 • Fallston, MD 21047 • USA

FOR UNDER \$10K

Email: sales@monolithic.com
Assembly time approx. 500 hrs.

Homebuilt HELICOPTERS 2 for 1 Special
G-1 400 Kiteflier IIIC EYCAM
Only \$25.99!
(Add \$4 post, Foreign add \$8)
(For Catalog only, send \$10)

24-HOUR ORDERING:
www.monolithic.com/order
BY PHONE: 1-800-668-5111
VORTech, Inc. • PO Box 5114 • Fallston, MD 21047 • USA

FOR UNDER \$10K

Email: sales@monolithic.com
Assembly time approx. 500 hrs.

Homebuilt HELICOPTERS 2 for 1 Special
G-1 400 Kiteflier IIIC EYCAM
Only \$25.99!
(Add \$4 post, Foreign add \$8)
(For Catalog only, send \$10)

24-HOUR ORDERING:
www.monolithic.com/order
BY PHONE: 1-800-668-5111
VORTech, Inc. • PO Box 5114 • Fallston, MD 21047 • USA

FOR UNDER \$10K

Email: sales@monolithic.com
Assembly time approx. 500 hrs.

Homebuilt HELICOPTERS 2 for 1 Special
G-1 400 Kiteflier IIIC EYCAM
Only \$25.99!
(Add \$4 post, Foreign add \$8)
(For Catalog only, send \$10)

24-HOUR ORDERING:
www.monolithic.com/order
BY PHONE: 1-800-668-5111
VORTech, Inc. • PO Box 5114 • Fallston, MD 21047 • USA

FOR UNDER \$10K

Email: <a href="mailto

buildings

**THE GARAGE/WORKSHOP OF YOUR DREAMS
— PRICED FOR IMMEDIATE SALE —**

Order your Miracle Truss Pre-engineered Steel Frame Building System TODAY and with our SPECIAL OFFER (below) you'll SAVE THOUSANDS!

Immediate Delivery Available — or ask about our Deferred Delivery/Storage Program.



Fast & easy do-it-yourself assembly · Designed to withstand severe weather · Available in 19 colors

SPECIAL LIMITED OFFER

30' x 36' (\$12,608 value)

Includes steel frames & endwalls, galv. sheeting, hardware, trim and complete assembly plans.

**NOW
ONLY
\$6,815**

Other building sizes available at great prices too!



CALL TODAY 1-800-663-0553
www.miraclettruss.com

STEEL BUILDINGS

Tough, rugged building — lasts !



- many sizes and shapes
- easy finish clear span interiors
- unique foundation, base connector

- industry leading cut-and-bolt system · no expensive equipment or tools needed
- easy friendly instructions
- factory direct toll free help line
- 30 year warranty
- totally maintenance free

SUPER SALE!

Up To

50% OFF

WE DELIVER WHAT WE PROMISE



Call Factory Direct and Save
800-668-5422
22 YEARS OF REPUTATION MADE OF STEEL

audio/video/films

M⁷ Black Holes

Audio
Images
of
Sparkling
Clarity

home-theater.
stereo-speakers.com

Get the sound you want

Home or car — stereo or Dolby® Digital — a DVD player or MP3 player, the Crutchfield catalog has it all, plus the information and service you need to buy with confidence.

Call toll-free today!

1-888-603-2693

Online? Visit our website:

www.crutchfieldcatalog.com and enter code "PS4"

CRUTCHFIELD

The best selection and service for 28 years



**It's
Free!**

audio/video/films

Micro Wireless Camera

World's smallest wireless video camera. Visit us online for this and other amazing products like... R/C aerial video systems, micro cameras, video transmitters, spy gadgets and more.

www.microcameras.com

automotive

**Drive with Hydrogen**

Convert your car. Schematics showing you how. Send \$19.00 check or MO to: ASI Corp., PO Box 597, Roanoke, VA 24783.

AMSOIL SYNTHETIC LUBRICANTS. BUY DIRECT. REGISTER TO BUY WHOLESALE. FREE CATALOG. 1-888-826-1166. www.synthol.com

HYDROGEN GENERATOR — DIRT SIMPLE! For auto home heating. Overview and technical data: \$19.95 BarTech/Dept. 15, 2580 Westminster Lane, Aurora IL 60506-1600

NEVER WAX YOUR CAR AGAIN! Patented system used by U.S. Navy. 866-395-7292 www.5starshine.com

VAPOR CARBURETOR TRIPLES MPG. Free information. H.A. R2PS Bowling Green, MO 63334-9350.

VORTEX™ FUEL-SAVER: AEROSPACE MATERIAL, FUEL-INJECTION VEHICLES. One-Size-Fits-All! \$65.95. 23 Garfield, Barre VT 05641

CARPAD FITS UNDER THE ENTIRE VEHICLE
1 INCH RAISED SIDES CONTAINS GALLONS OF WATER, SNOW, SALT, SAND & GRIME. CLEANS EASILY. SIZES ALL VEHICLES. AVAILABLE IN SILVER OR GOLD VINYL.

CALL CARPAD 1-800-635-7927
VISIT OUR INTERSTORE AT
WWW.CARPAD.COM

THE ULTIMATE IN GARAGE FLOOR PROTECTION SINCE 1991
VISA • MASTERCARD • AMERICAN EXPRESS • DISCOVER

AUTOCANOE Co.

"ROADABLE CANOES"™
Plans: \$200 incl. S & H within the US.
www.autocanoe.com
Mail money orders to: Autocanoe Co.
P.O. Box 310, Port Townsend, WA 98366

bbq equipment

TASTE THE DIFFERENCE
TRAEGER
Wood Pellet Grills
Smoke, Grill, BBQ, Bake
1-800-722-3437
www.traegerindustries.com

**beer/winemaking**

FREE HOMEBREWERS CATALOG -- Quality Beer/Winemaking supplies — Call today **WINDRIVER BREWING 1-800-266-4677** www.windrivervbrew.com

WINEMAKERS - BEERMAKERS. Free Illustrated Catalog. Since 1967. 1-800-841-7404. KRAUS, Box 7850-N, Independence, MO 64054. www.kraus.com/offers/h.asp

boats & equipment

BOATS PLANS & KITS: www.Glen-L.com Catalog: #95, Glen-L marine designs, 9152-PS33/Box 1804 Rosencrans Ave., Bellflower, CA 90705 562-630-0258

Pontoon Boats & Docks

Available In Kits Or Assembled
Assemble Your Own Boat Or Dock
Free Literature And Prices
Call Toll Free
1-800-722-4331
www.retley.com

Retty P.O. Box 261, Dept. 310 Colchester, IL 62326

books/publications

15,000 Pages PROVEN INTERNET MARKETING TECHNIQUES and SECRETS! Bonus offer! www.top150books.com/150gyleshall.com

ANTI-TERRORISM BOOK!! INFO \$1 JGCO, PO BOX 455, SEBRING, FL 33871

The Shadowmaster Series of romantic, interstellar adventures; something different, from ninjabearpress.com

business opportunities**INK JET REFILLING!!!****START YOUR OWN BUSINESS**

- Training & Equipment
- 80% Profit Margins
- Home, Mobile or Store
- Local & National Financing
- International Shipping

1.512.339.8213 x117
www.RamoraU.com



\$1,000'S WEEKLY mailing burglar alarm advertisements FREE supplies/postage! SASE: Listings-PB, Box 699, Lake Zurich, IL, 60047

\$400 WEEKLY ASSEMBLING PRODUCTS from home. For free information send SASE: HOME ASSEMBLY-PS Box 216, New Britain, CT 06050-0216.

BUY FORECLOSED PROPERTY! USE OUR MONEY! SPLIT PROFITS! TRAINING! FREE INFORMATION: 1-800-331-4555 EXT.123.

Lil' BUBBA
Create your own business
creating custom
landscape borders
Call for a
free video
and catalog!
www.lilbubba.com

The Concrete Edge Company
(800) 314-9984 (407) 656-2788 www.lilbubba.com

business opportunities

CRAPS! Amazing, revolutionary system. Thousands of satisfied customers. Free recorded information. 1-800-217-7711.

DIRECT SELL COMMUNICATIONS OVERVIEW: START NOW! You'll find this EXTREMELY LUCRATIVE over next 1-3 years. www.globalsuccess2000.com/sellers

MAKE EXTREME CHUNKS OF CASH With Your Computer! POWERFUL Details Rush \$3 S.O.W. Publishing BOX#40884/P/S6 Staten Island NY 10304

RECORD VIDEOPIES AT HOME! Easy \$1800.00 Weekly Income! Free Startup Information Kit! (205)663-9888 CMSVIDEO, Dept. 152, 210 Loma Square, Birmingham, AL 35216-5439

REPAIR CRACKED WINDSHIELDS

Earn \$90,000 Yearly Repairing
-not replacing-

Large Cracks in Windshields
CALL 1-800-826-8523

or write The Glass Mechanix
<http://www.glassmechanix.com>

4555 NW 103rd Ave. • Ft. Lauderdale, FL 33351

REVOLUTIONARY BREAKTHROUGH Rotary Jet Extraction Carpet Cleaning System. Check It Out! www.rotovac.com 888-768-6822

TAKE CONTROL OF YOUR FUTURE!! Work From Home S-E-S PFTF -- Complete training. Free Information 1-888-286-0620/www.ENDLESSPROSPERITY.com

TURNKEY ADULT WEBSITES only \$495. 900 NUMBERS just \$99 each. FREE BROCHURE. 1-888-850-6131/www.satumcommunications.com

U.S. CO. WITH ROOF-TOP ENERGY SYSTEM will train management candidates to work from home (Manager: \$81k, average + \$800/month car allowance) 888-895-6900

education/instruction

Best Quality -- 400 Different University Diplomas, Certificates. No Studying. Satisfaction Guaranteed. [P.O. Box 6188, Huntington Beach CA 92615. Letsucces@nol.com](http://www.letsucces.com) Fax 714-444-9706

Ph.D.'s \$495.00, M.A.'s \$395, J.D.'s \$450. FOR FREE INFORMATION, CALL 1-800-587-9605 <http://www.universitydegree.com>

CITIZENS' HIGH SCHOOL
Earn Your Diploma In As Little As Four Months!
• Non-Credit Academic Self-Paced Learning
• Grades 9-12 • Home Study
• Visit Us At www.citizenschool.com
For a Free Brochure, Call Dept. PS Toll Free:
1-800-736-GRAD
ORANGE PARK, FLORIDA

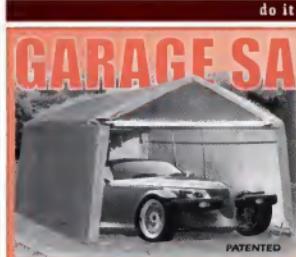
electronic supplies & equipment

PRINTED CIRCUIT BOARDS: Design/Layout Fabrication and Assembly since 1983. 406-565-8000/600-726-5871 email: midtech@jolt.net

energy sources & savers
\$4 INDEPENDENT ENERGY CATALOG
www.KansasWindPower.net 13569-P 214th Road, Holton KS 66463-8138

FREE ENERGY! Fuel-Less Motors and Generators! H&A, R2EPS Bowling Green, MO 63334-9350.

Clean Burnable Fuel
FROM WATER!
Fully Assembled Unit: \$119.95
Graphic Plans: \$20.00
Graphic Info Pkg: \$10.00
Midwest Hydrogen
P.O. Box 3155, Duluth, MN. 55803



COVERIT **CALL NOW! 1-800-421-6474**

HYDRAULIC JACK REPAIR Manual and catalog: \$10.00. 620-594-2247. Hydraulic Parts Supply, PO Box 97-PS, Sawyer KS 67134.

POWERFUL MINI SKID STEER plans FREE information. Email: privessolve@netscape.net PO Box 360854 Dept. PS703 Grinnell, IA 5044136

financial

COMPUTER ERASE BAD CREDIT, DUE - FREE INSTANTLY add Triple AAA credit OVERNIGHT! www.computererase.com

Credit Cards, Loans, Bills Overdue?

Bad credit? no problem! Applications accepted to \$50,000. Licensed/Bonded Debt Management since 1977

1-800-403-1085

FREE CASH GRANTS. NEVER REPAY. ANY PURPOSE. THOUSANDS OF SOURCES. CALL FREE 1-800-287-8066.

FREE GOVERNMENT BUSINESS KIT-GRANTS-LOANS EBAY MERCHANDISE AUCTION KIT FREE MERCHANT ACCOUNT 800-306-8373 <http://www.capitalpublications.com>

flag/flagpoles**FLAG-WORKS OVER AMERICA****FLAG POLES**

American Flags - State - International
Historical - Military - Custom
FREE Catalog 1-800-580-0009

www.flag-works.com

games, toys & models**STEAM MODELS**

AVAILABLE IN KITS OR ASSEMBLED
Scales 1/8, 1/16, 1/32, 1/64

Over 150 Different Working Model
Steam Engines, Accessories & Parts.

STUNNING 43 PAGE COLOR www.yesterdays-toys.com

YESTERDAY'S TOYS
DEPT. PS • BOX 137, ALEXANDRIA BAY, NY 13607

1-800-481-1353 www.yesterdays-toys.com

gardening/lawn care

www.hydroponicsgarden.com Larger Harvests year-round! Grow lights & gardening equipment.

FREE CATALOG 1-800-8-669-5483

health & fitness**DIGITAL CUSTOM HEARING AIDS-FREE CATALOG!**

Powerful Custom Aids, B.T.E.'s Top Brands, All Styles. Repair Service and Accessories. Save 1/2 or More!

Power Hearing P.O. Box 13885

Cheapeake, VA 23325-0885

1-800-260-4135

www.powerhearing.com

Save 1/2 or More!

do it yourself

Limited Time!

Reg. \$780

\$399

12'x20'x8'

House or Round Style

FREE Double Zipper Door

10-15 Year Life Expectancy

2 YEAR WARRANTY*

30 DAY MONEY BACK**

*Ask for details

**Less S&H

IN STOCK AND READY TO GO!

Other sizes available.

Call 1-800-421-6474

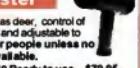


www.coverit.com

**LaserWindow
Bounce & Optical
Communicator**

Laser illuminating and optical receiver available as kits or ready to use modules for retrofitting into a science project or field worthy laser listening system... Includes 10 mw infra red laser with collimator and test tone circuit, visible red laser for signing and optical receiver with lens. Plans show the basics to complete a working system.

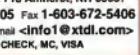
LWB Plane.....\$20.00 LWB9K Kit of the above.....\$299.95
LWB90 Ready to use assembled modules.....\$449.95

Phaser Wave Blaster

For control of several pens such as deer, control of dogs, cats etc. Directional and adjustable to target subject. CAUTION not for people unless no other defense. Rental units available.

PPPK Kit/plans....\$49.95 PPP 10 Ready to use....\$79.95

See hundreds of amazing products at <http://www.amazing1.com>

Info Unlimited

Box 716 Amherst, NH 03031

Office/Freecat 1-800-221-1710 Fax 1-603-672-5406

Teachline 1-603-673-4374 Email <info1@xtel.com>

We Accept Cash, MO, CHECK, MC, VISA

See hundreds of amazing products at <http://www.amazing1.com>

Info Unlimited

Box 716 Amherst, NH 03031

Office/Freecat 1-800-221-1710 Fax 1-603-672-5406

Teachline 1-603-673-4374 Email <info1@xtel.com>

We Accept Cash, MO, CHECK, MC, VISA

See hundreds of amazing products at <http://www.amazing1.com>

Info Unlimited

Box 716 Amherst, NH 03031

Office/Freecat 1-800-221-1710 Fax 1-603-672-5406

Teachline 1-603-673-4374 Email <info1@xtel.com>

We Accept Cash, MO, CHECK, MC, VISA

See hundreds of amazing products at <http://www.amazing1.com>

Info Unlimited

Box 716 Amherst, NH 03031

Office/Freecat 1-800-221-1710 Fax 1-603-672-5406

Teachline 1-603-673-4374 Email <info1@xtel.com>

We Accept Cash, MO, CHECK, MC, VISA

See hundreds of amazing products at <http://www.amazing1.com>

Info Unlimited

Box 716 Amherst, NH 03031

Office/Freecat 1-800-221-1710 Fax 1-603-672-5406

Teachline 1-603-673-4374 Email <info1@xtel.com>

We Accept Cash, MO, CHECK, MC, VISA

See hundreds of amazing products at <http://www.amazing1.com>

Info Unlimited

Box 716 Amherst, NH 03031

Office/Freecat 1-800-221-1710 Fax 1-603-672-5406

Teachline 1-603-673-4374 Email <info1@xtel.com>

We Accept Cash, MO, CHECK, MC, VISA

See hundreds of amazing products at <http://www.amazing1.com>

Info Unlimited

Box 716 Amherst, NH 03031

Office/Freecat 1-800-221-1710 Fax 1-603-672-5406

Teachline 1-603-673-4374 Email <info1@xtel.com>

We Accept Cash, MO, CHECK, MC, VISA

See hundreds of amazing products at <http://www.amazing1.com>

Info Unlimited

Box 716 Amherst, NH 03031

Office/Freecat 1-800-221-1710 Fax 1-603-672-5406

Teachline 1-603-673-4374 Email <info1@xtel.com>

We Accept Cash, MO, CHECK, MC, VISA

See hundreds of amazing products at <http://www.amazing1.com>

Info Unlimited

Box 716 Amherst, NH 03031

Office/Freecat 1-800-221-1710 Fax 1-603-672-5406

Teachline 1-603-673-4374 Email <info1@xtel.com>

We Accept Cash, MO, CHECK, MC, VISA

See hundreds of amazing products at <http://www.amazing1.com>

Info Unlimited

Box 716 Amherst, NH 03031

Office/Freecat 1-800-221-1710 Fax 1-603-672-5406

Teachline 1-603-673-4374 Email <info1@xtel.com>

We Accept Cash, MO, CHECK, MC, VISA

See hundreds of amazing products at <http://www.amazing1.com>

Info Unlimited

Box 716 Amherst, NH 03031

Office/Freecat 1-800-221-1710 Fax 1-603-672-5406

Teachline 1-603-673-4374 Email <info1@xtel.com>

We Accept Cash, MO, CHECK, MC, VISA

See hundreds of amazing products at <http://www.amazing1.com>

Info Unlimited

Box 716 Amherst, NH 03031

Office/Freecat 1-800-221-1710 Fax 1-603-672-5406

Teachline 1-603-673-4374 Email <info1@xtel.com>

We Accept Cash, MO, CHECK, MC, VISA

See hundreds of amazing products at <http://www.amazing1.com>

Info Unlimited

Box 716 Amherst, NH 03031

Office/Freecat 1-800-221-1710 Fax 1-603-672-5406

Teachline 1-603-673-4374 Email <info1@xtel.com>

We Accept Cash, MO, CHECK, MC, VISA

See hundreds of amazing products at <http://www.amazing1.com>

Info Unlimited

Box 716 Amherst, NH 03031

Office/Freecat 1-800-221-1710 Fax 1-603-672-5406

Teachline 1-603-673-4374 Email <info1@xtel.com>

We Accept Cash, MO, CHECK, MC, VISA

See hundreds of amazing products at <http://www.amazing1.com>

Info Unlimited

Box 716 Amherst, NH 03031

Office/Freecat 1-800-221-1710 Fax 1-603-672-5406

Teachline 1-603-673-4374 Email <info1@xtel.com>

We Accept Cash, MO, CHECK, MC, VISA

See hundreds of amazing products at <http://www.amazing1.com>

Info Unlimited

Box 716 Amherst, NH 03031

Office/Freecat 1-800-221-1710 Fax 1-603-672-5406

Teachline 1-603-673-4374 Email <info1@xtel.com>

We Accept Cash, MO, CHECK, MC, VISA

See hundreds of amazing products at <http://www.amazing1.com>

Info Unlimited

Box 716 Amherst, NH 03031

Office/Freecat 1-800-221-1710 Fax 1-603-672-5406

Teachline 1-603-673-4374 Email <info1@xtel.com>

We Accept Cash, MO, CHECK, MC, VISA

See hundreds of amazing products at <http://www.amazing1.com>

Info Unlimited

Box 716 Amherst, NH 03031

Office/Freecat 1-800-221-1710 Fax 1-603-672-5406

Teachline 1-603-673-4374 Email <info1@xtel.com>

We Accept Cash, MO, CHECK, MC, VISA

See hundreds of amazing products at <http://www.amazing1.com>

Info Unlimited

Box 716 Amherst, NH 03031

Office/Freecat 1-800-221-1710 Fax 1-603-672-5406

Teachline 1-603-673-4374 Email <info1@xtel.com>

We Accept Cash, MO, CHECK, MC, VISA

See hundreds of amazing products at <http://www.amazing1.com>

Info Unlimited

Box 716 Amherst, NH 03031

Office/Freecat 1-800-221-1710 Fax 1-603-672-5406

Teachline 1-603-673-4374 Email <info1@xtel.com>

We Accept Cash, MO, CHECK, MC, VISA

See hundreds of amazing products at <http://www.amazing1.com>

Info Unlimited

Box 716 Amherst, NH 03031

Office/Freecat 1-800-221-1710 Fax 1-603-672-5406

Teachline 1-603-673-4374 Email <info1@xtel.com>

We Accept Cash, MO, CHECK, MC, VISA

See hundreds of amazing products at <http://www.amazing1.com>

Info Unlimited

Box 716 Amherst, NH 03031

Office/Freecat 1-800-221-1710 Fax 1-603-672-5406

Teachline 1-603-673-4374 Email <info1@xtel.com></p

Baldness Cure?

"Small Company Claims Solution Found"

Millions of dollars in loss revenue will occur in the surgical hair transplant industry if a small company succeeds in marketing a dermal hair grafting solution called MediHair.

MediHair can be induced, without surgery, into thinning or bald areas of the scalp. An individual hair stabilization is achieved with no healing or recovery period. Thinning hair can be thickened and hairlines fully restored with no removal of healthy hair as in the case of surgical hair transplants.

Company spokesperson concedes that the medical

profession will not help to promote or market this discovery because of the potential of lost revenue. "Who would ever want hair transplants?" Since no surgery is needed, MediHair is safe, painless and affordable to all.

"Since we are a small company, we can guarantee results and even without the help of the medical profession, we can market MediHair through word-of-mouth advertising."

For availability of MediHair, the company does have a toll-free number and a free brochure, just call 1-800-311-4597.

ENJOY HEARING!

MINI-CANAL

BTE

\$199 & UP

FREE CATALOG!

- 45 Day Trial • Huge Savings
- 1-800-320-3300 EXT R31
- Write: RHODES HEARING**
- 20131 Ohio St. Brookport, IL 62910

PURE WATER MADE SIMPLE... Homemade distilled is best! FREE CATALOG. 1-800-874-9026. www.watertwise.com

help wanted

EASY WORK! EXCELLENT PAY! ASSEMBLE PRODUCTS AT HOME. TOLL FREE 1-800-467-5566. EXT. 8068.

homeowners

DO-IT-YOURSELF MULTIMEDIA CONTROL PANELS: VOICE, DATA, SAT-TV, 1-866-961-TECH VISIT <http://www.mcs.tohomenet> -DEALERS WELCOME.

Inventors & inventions

Market Your Invention!

Free report reveals how to bring your invention to market. Finally! Make money from your invention.

Call: 800-291-4501

24 hours for a free recorded message.

1st-to-Invent protection/instruction kit FREE. No fees required. 1-800-651-9679 www.ideaheads.com

AMERICA'S LEADING invention company helps submit ideas/inventions to industry. Patent Service. 1-888-439-IDEA.

Have a Bright Idea?

Now OWN IT for only \$129

Created by Gene Scott, Reg. Patent Agent & Ceo, Worldwide Technology & Business Directory

- Provides "patent pending" status
- Easy, quick to do
- Avoid attorney fees
- Filing fee only \$80

Do-It-Yourself ACTION KIT™
Provisional Patent Application
Kit inc. Video, Workbook, Examples and Forms

Patent Law & Venture Group

1-800-747-2836

PatentABC.com & ventureABC.com

IF YOU CAN DREAM IT, WE CAN BUILD IT. Let PROTO-TECH design and build prototypes of your electronic invention. Essential for marketing and raising capital. www.proto-tech.com

INVENTORS FREE ADVICE. EARN THOUSANDS TOTAL PRIVACY WRITTEN GUARANTEES, MARKETING PATENTING MANUFACTURING, LICENSING 1-800-841-1708

REGISTERED PATENT ATTORNEY. Free consultation, reasonable fees. Bruce Weir at www.bruceweir.com Toll-free 1-866-524-8395

Inventors! FREE Internet Service WORLDWIDE INVENTION DIRECTORY

- List Your Invention (Technical Disclosure Not Required)
- Exposure To 200,000 Manufacturers
- Effective Funding Searches
- Extraordinary Income Opportunity
- Signup Bonus

www.InventionTrader.com

kites

KITES!



Fly your colors sky high.

Free 80 page Catalog with hundreds of unusual kites, flags and windsocks.

Into The Wind • (800) 541-0314

1408-P Pearl St., Boulder, CO 80302

www.intothewind.com

musical instruments

DEERING, the Great American Banjo Company, offers limited supply of QUALITY BANJOS from \$299. FREE CATALOG (800) 845-7791 Ext. PS

new products

i-glasses™ HRV

High Res Video Headset
Connects To Any Video Source
2X the Resolution of Standard TV

I-O Display Systems

(800) 339-5287

www.i-glasses.com

Mention this ad
for 10% discount

ECONOMICAL SPIRAL STAIR KITS. Patented all-wood design. Precision Pine Inc. 877-885-8902 www.spiralstaircase.com

ROCKET FUEL COFFEE High Caffeine Coffee Finish Projects Fast!! Z-COFFEE Corporation 1-800-828-4064 www.z-coffee.com

STOP FLOOR SQUEAKS

Squeeeek More® floor squeak elimination kit is now available at retail stores. Call 800-459-8428

for a store near you or
www.squeaknomore.com

O'Berry Enterprises Inc.

5306 Business Pkwy#10 Ringwood, IL 60072

CAD LOADER

Build It Yourself
Front End Loader

Buy Plans & Video

Build for under \$700 with

available Kit for your garden

tractor. No machining

CAD Loader

www.CADLoader.com

P.O. Box 606, Dept. S • Deleville, VA 24063 • 1-800-817-5267



new products

SUPER-BRIGHT SOLID-STATE NIGHT LIGHTS
DISTINCTIVELY CREATED TO BE BOTH FUNCTIONAL
AND BEAUTIFUL IN ANY HOME ENVIRONMENT. VISIT
OUR WEBSITE: WWW.HOLLYWOODLIGHTING.COM

 Your Opinions
on our emblems
www.EvolveFISH.com
Caps, Stickers, Emblems
Shirts & much more 
800-386-5846

of interest to all

Beautiful Celebrity Photos. Free catalog. Acme Publications/
PS2 Box 130387, St. Paul, MN 55113

CAREFUL! HIDDEN FACTS! Jehovah's Witnesses. Free,
Confidential, Box454, Meteline Falls, WA 99153
www.maccg.org/ministries.org

YourHow2source.com - #1 Premier source for
build-it-yourself plans and In demand information!

MEN'S WIDE SHOES EEE-EEEEEE, SIZES 5-13

- High quality
- 200 styles
- FREE catalog



HITCHCOCK SHOES, INC.
Dept. 46H Hingham, MA 02043
1-800-992-WIDE www.wideshoes.com

plans/kits/blueprints



Universal Electric Bike
Complete Kit
only \$445.00

Go up to 20 mph
for 20 miles
without pedaling

Universal gearless, 400 watt hub motor
Easy installation
Lifetime warranty! www.ubike.com

Complete Bike only \$575

(normal 22 x 14 x 30 inches) To order: www.ubike.com

Order now! Call 1-800-992-WIDE

www.ubike.com

Toll Free: 1-800-992-WIDE

Our newest product!

www.ubike.com

Toll Free: 1-800-992-WIDE



Pedelec-Electric City Car

Front-wheel drive - two 400 watt motors
20 mph

Only \$1195

\$995 without electric power

www.ubike.com

Toll Free: 1-800-992-WIDE

real estate

MONTANA, WYOMING & NEW MEXICO

20 Acres. Average monthly payment only \$285.
Easy Owner Financing. No Time Limit Guarantee.
Guaranteed Access. Insured Title.

Free Information: 1-800-682-8088
Rocky Mountain Timbers
Dept PS, P.O. Box 1153 • Bozeman, MT 59771-1153

406-586-9068 • New Mexico: 505-720-3018

CALIFORNIA ACREAGE Lots \$50 down, \$50 monthly. 4602
Ethel Ave., Sherman Oaks, CA 91423

**FORECLOSURES! LAND! HOMES! APARTMENTS!
BUILDINGS!** Millions Available in Real Estate for pennies!
100% Guaranteed See: www.dolitress.com

GOVERNMENT LAND U.S. CITIZENS ONLY

20-160 acre claim program still available, get yours for \$20
government fee, in AK, AZ, AR, CA, CO, ID, MT, NV, NM, OR,
UT, WA, WV. For complete, step-by-step package including
maps, telephone help, film, forms, etc. \$200; or for
more information send \$3. PUBLIC LANDS TIME, PO Box
2945-PS Port Angeles, WA 98362-0336 (this is not
Homesteading, it's much easier and only costs \$1 per acre).
<http://www.governmentland.com>

phones

Dropped Calls? Cell Phone Reception Problems?

www.CellAntenna.com

Toll Free 1-877-450-5707

scooters

TANAKA POWERBOARDS Electric/Gas Scooters
Economical, Fast, Fun, Safe, Customizable, Upgradable,
www.paverrunners.com

science & physics

AMAZING NEW WEBSITE: www.advanced-scientific.com
Chemicals, Laboratory & Educational Supplies- Advance
Technology 1-800-242-2436

AMERICAN SCIENCE & SURPLUS. Electronic and
mechanical components, lab equipment, materials, tools,
kits, hardware, military more! Free catalog: 847-982-0870
<http://www.sciplus.com>

EXPERIMENTERS- CHEMICALS-LABWARE.
GLASSWARE- Formerly HAGENOW LABS.
New: ELEMENTAL SCIENTIFIC P.O.Box 571, Appleton, WI
54912 Catalog \$2.00 www.elementalscientific.net

NEODYMIUM MAGNETS
Surplus and
Strongest Known!
FORCEFIELD (877)-944-6247
www.wondermagnet.com

"HOBBYIST CHEMICALS" Lab glassware, Acids, Solvents &
Supplies. Rockery & Special effects chemicals-Highest
quality-lowest cost. Hundreds of items. "HUGE CATALOG"
\$3.00. PYROTEK, R.R.2 Box 2520B, Hallstead, PA 18822.
(570)879-2580. www.pyrotek.org

Laboratory Supplies: Glassware, microscopes, tubing,
scales, test tubes, cork, clothing and MUCH more! Affordable
laboratory goods for 65 years. www.labwarehouse.com

security & survival

GOTTCHA!
Caught in the Act!
Protect your children,
home, business!
AmericanTechnicalSupply.com
800-968-3024

WIRELESS HIDDEN CAMERAS

in briefcases, books, sunglasses, clocks and
more. Plus full line of self defense products.

Distributors wanted. We drop ship.
(904) 720-2188 www.safetytechnology.com/ps

Safety Technology 1867 Caravan Trail #105, Jacksonville, FL 32216



More and more people are looking
for a superior steel building and
POPULAR SCIENCE is a great way
for us to reach them!

FUTURE STEEL BUILDINGS

security & survival

When your home air conditioner fails, have your computer
e-mail you before your pets suffer. Monitor temperature,
humidity, alarms, etc.: \$179. www.WeatherDuck.co.uk in Europe.

selfdefensedepot.com

AWESOME SELF-DEFENSE PRODUCTS • UNIQUE
SPY EQUIPMENT • NAME YOUR OWN PRICE
PINHOLE CAMERAS • MARTIAL ART • WATERLESS
CAMERAS • ALL WHOLESALE!

Machete International, Inc.
1844 N. Nolte • Suite 100 • Ft. Lauderdale, FL 33319,
866-779-2499

Print
Catalog \$3.00
(REFUNDABLE)

WIRELESS DRIVEWAY ALARM

An alert will sound in
your home or workshop
anytime someone ap-
proaches the house.
Never miss a visitor
while you're working on a
project.



Free Literature- A complete line of wireless
security equipment & weather products.

DAKOTA ALERT, INC.

Box 130, Elk Point, SD 57025 • Ph: 605-356-2772
www.dakotaalert.com

surplus

***TOOLS!! *LAND!! *TRUCKS!! *CARSS! MOTORCYCLES!!**
MILLIONS AVAILABLE IN GOVERNMENT
SURPLUS FOR PENNIES! See: www.govsurplus.com
100% guaranteed!

television

FREE Satellites TV Buyer's Guide! BIG DISHES- BIG DEALS!
Get the MOST free and subscription channels with C-band
digital upgrade! SKYVISION. 800-543-3025. International: 182-739-5231 www.skyvision.com

Satellite Programming Package, get more channels
including PayPerView, Premium, Sports \$99.95 24-Hours
www.programpack.com

SCRAMBLING NEWS. Best satellite news source covers
piracy. www.scramblingnews.com Free catalog,
1-954-432-7943

tools & machinery

4" Metal Cutting Lathe \$149.60. Teig, 12419 Nightingale Lane,
Chandler, AZ 85249.

FREE CATALOG of machine tool shops including lathes, mills,
drill presses, Blue Ridge, PO Box 536, Hurricane, WV
25526. www.blueridgemachinery.com, 800-872-6500.

water purification

MAKE PURE WATER & SAVE \$\$\$ NEW REVERSE
OSMOSIS with TDS meter. Whole house filters.
Replacement Filters for most brands, FREE CATALOG
1-888-295-9436, info 1-888-633-7972 www.FilterDirect.com
www.WaterGeneral.com

**Home Appliance Makes
Drinking Water**
FREE Information Packet
1-800-874-9028
www.waterwise.com

JANUARY 1931

We advised "thrill seekers looking for something new to try" to check out Viennese daredevil Joseph Krupka's wing-enhanced skiing technique. Krupka skied partway down a glacier, then tilted his aluminum wings and "for hundreds of feet soared over the snowy tracks, landing near the foot of the slope." The practice of enhancing a traditional sport by adding wings has endured; witness how intrepid modern-day "skyfliers" have expanded skydiving (see page 54). These swooping, be-winged adventurers eventually hope to glide all the way back to earth. Echoing Krupka, one idea is to land with skis on a snowy slope.

Popular Science

Founded MONTHLY 1872

25 CENTS

JANUARY



See Page 69

\$2,000 IN CASH PRIZES
See New Picture Contest Page 27

Photography Permission: Permission is granted by Popular Science, Inc., to business and others represented by the Copyright Clearance Center (CCC) to photocopy articles in this issue for the flat fee of \$1 per copy of each article or any portion thereof. Send payment to CCC, 27 Congress St., Salem MA 01970, specify CCC, D1 Congress St., Salem MA 01970, specify CCC, code 0143-2370/85/01 00-00-00. Copying done for other than personal research use without the written permission of Popular Science is prohibited. For information on requests for Second Class postage, write to Timed Media, Inc., 2 Park Ave., New York NY 10016 for foreign requests. For domestic requests, write to Popular Science Publishing Service Inc., 1811 Olde Homestead Ln., Lancaster PA 17601. 717-299-1901, ext. 109. © 1985 by Timed Media, Inc. PRINTED IN U.S.A. REFERENCE: Popular Science® is a registered trademark of Timed Media, Inc. Otherwise, we do not claim originality for material available from publicly screened companies that offer products and services we believe would interest our readers. If you do not want to receive these offers and/or information, please advise us at P.O. Box 51286, Boulevard CO 80323-2286. POPULAR SCIENCE is published monthly by Popular Science Publishing Service Inc., 1811 Olde Homestead Ln., Lancaster PA 17601. Editorial Offices: Address contributions to Popular Science, Editorial Dept., 2 Park Ave., New York NY 10016. We are not responsible for loss of unsolicited materials. They will not be returned unless accompanied by return postage. Mailed matter postage paid at Bronx, New York, Post Office, and additional postage paid at Bronx, New York, Post Office, and additional postage paid at Bronx, New York, Post Office. Second class postage paid at Bronx, New York, Post Office, and additional postage paid at Bronx, New York, Post Office. Canada Post Catalogue No. A69951. Canadian GST Registration Number R122988006. Popular Science (ISSN 0143-2370) is published monthly by Timed Media, Inc., 2 Park Ave., New York NY 10016. Printed in U.S.A. © 1985 Timed Media, Inc.

TURBOMAN

60



WAVE®

SPECS

- NEEDLENOSE PLIERS
- REGULAR PLIERS
- WIRE CUTTERS
- HARD-WIRE CUTTERS
- CLIP-POINT KNIFE
- SERRATED KNIFE
- SAW
- DIAMOND-COATED FILE
- CROSS-CUT FILE
- SCISSORS
- XS/S/M/L SCREWDRIVERS
- PHILLIPS SCREWDRIVER
- BOTTLE/CAN OPENER
- WIRE STRIPPER
- LANYARD ATTACHMENT



What kind of **man are you?**

When you want high performance, who do you turn to? The multi-tool experts at Leatherman. Our tools have a solid record of precise engineering, durability and convenience. They're ready for anything, from rebuilding your transmission to replacing a vanity plate. With the features-packed Wave®, you'll be ready to handle any job down the road—and beyond.

LEATHERMAN®

Explore the world of Leatherman at www.leatherman.com or call 1-800-762-3611 for a Leatherman dealer near you. Available in sporting goods and hardware departments of retailers nationwide.



Get that new planet smell.



Thanks to our super-efficient Hybrid Synergy Drive, the gas/electric Prius has all the performance of a conventional car while running up to 89% cleaner

Powered by



for smog-forming emissions. It's also surprisingly affordable and you never have to plug it in. Take a deep breath. The new Prius is on its way.

Coming this Fall.
toyota.com/newprius

PRIUS START NOW.

TOYOTA

GET THE FEELING